UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT TRIAL AND APPEAL BOARD

BOE TECHNOLOGY GROUP CO., LTD.

Petitioner

v.

BISHOP DISPLAY TECH LLC

Patent Owner

Case No. IPR2025-01331
Patent No. 8,093,830

DECLARATION OF ALEX Z. KATTAMIS, PH.D., P.E.

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I. INTRODUCTION

1. My name is Alex Kattamis. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters contained herein.

2. I am over the age of 21 and am competent to make this declaration.

3. I have been retained by Ropes & Gray LLP on behalf of BOE Technology Group Co., Ltd., to provide technical assistance in the inter partes review of U.S. Patent No. 8,093,830, which I may abbreviate as **"the '830 Patent"** or refer to as the **"Challenged Patent."** This declaration is a statement of my opinions on issues related to the unpatentability of claims of the Challenged Patent.

4. I am a salaried employee of Exponent. Exponent charges $575 per hour for my time plus expenses for work performed in connection with this project. I have received no additional compensation for work in this case, and my compensation does not depend upon the contents of this report, any testimony I may provide, or the ultimate outcome of the case.

II. EXPERIENCE AND QUALIFICATIONS

5. In formulating my opinions, I have relied upon my knowledge, training, and experience in the relevant art. My qualifications are stated more fully in my curriculum vitae, which has been provided as Appendix A. My CV also lists publications on which I am a named author and identifies parties on behalf of whom I have previously provided expert testimony within the past four years. Here, I provide a brief summary of my qualifications.

6. I am a Principal Engineer in Exponent's Electrical Engineering and Computer Science practice. I received my B.A. in Electrical Engineering from the University of Connecticut in 2002 and an M.A. and Ph.D. in Electrical Engineering from Princeton University in 2004 and 2007, respectively.

7. During my time at the University of Connecticut and through a grant from the National Science Foundation, I designed and implemented devices for people with disabilities. This included the design and manufacture of analog and digital control systems for devices including go-karts and electronic lifts.

8. Before joining Princeton University, I worked as a design engineering intern at General Electric Industrial Systems. There I designed and implemented analog and digital circuits. This work included the implementation of current sense devices for feedback in power supplies.

9. At Princeton University, my research was focused on designing and fabricating pixel circuits on non-conventional substrates for driving liquid-crystal displays ("LCDs") and active-matrix organic light emitting diode displays ("AMOLEDs").

10. Throughout my career at Exponent, I have worked extensively on AMOLED and LCD displays including backlight systems based on LEDs, driver circuits, thin-film transistor and pixel architectures, and waveguides.

11. I am a licensed Professional Engineer in the State of Connecticut, the State of Georgia, the Commonwealth of Massachusetts, the State of New Jersey, the State of New York, the Commonwealth of Pennsylvania, the State of Rhode Island, and in the State of Texas. I am also designated as a Model Law Engineer by the National Council of Examiners for Engineering.

12. I am a Senior Member of the Institute of Electrical and Electronics Engineers ("IEEE"), which is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity.

13. Therefore, based on my education, professional experience, scholarly books and publications, I am an expert in the relevant field of the Challenged Patent at issue here and have been an expert in this field since before the Challenged Patent was filed with the United States

Patent and Trademark Office (USPTO). I am familiar with how a person having ordinary skill in the art would have understood and used the terminology found in the Challenged Patent at the time of its filing.

III. TASK SUMMARY AND MATERIALS REVIEWED

14. I have been asked to review the Challenged Patent and its prosecution history, to provide an understanding of the technology relevant to the Challenged Patent, to review certain prior-art references, and analyze whether or not those references disclose or teach limitations of claims from the Challenged Patent. The opinions stated in this declaration are from the perspective of a person of ordinary skill in the art.

IV. LIST OF EXHIBITS

15. In forming my opinions, I have reviewed the Challenged Patent, its prosecution history and referenced cited by the Examiner, the materials cited in the List of Exhibits, and the materials cited throughout my declaration.

Ex.	Description of Exhibits
1001	U.S. Patent No. 8,093,830 ("'830")
1002	File History of U.S. Patent No. 8,093,830 ("'830FH")
1004	U.S. Patent No. 6,285,139 ("Ghanem")
1005	U.S. Patent No. 7,332,699 ("Nishimura")
1006	U.S. Patent No. 7,262,559 ("Tripathi")
1007	U.S. Patent Pub. No. 2003/0173910 ("Suzuki")
1009	Paul Horowitz et al., THE ART OF ELECTRONICS, 2nd ed. (Cambridge University Press: 1989), ISBN: 0-521-37095-7 ("Horowitz Handbook")
1010	Kevin Warwick, AN INTRODUCTION TO CONTROL SYSTEMS, 2 ed., Vol. 8 in ADVANCED SERIES IN ELECTRICAL AND COMPUTER ENGINEERING (WORLD SCIENTIFIC PUBLISHING CO. PTC LTD: 1989), ISBN: 981-02-1563-0 ("Warwick Text")
1011	Steve Winder, POWER SUPPLIES FOR LED DRIVING, 1st ed. (Newnes: 2008), ISBN: 0-750683-41-4 ("Winder Text")

1012	U.S. Patent Pub. No. 2007/0091995 ("Ibragimov")
1013	U.S. Patent No. 8,090,198 ("Yoshii")
1014	Sergio Franco, DESIGN WITH OPERATIONAL AMPLIFIERS AND ANALOG INTEGRATED CIRCUITS, 3rd ed. (McGraw-Hill: 2002), ISBN: 0-07-232084-2 ("Franco Text")

Other than the prosecution history, Ex. 1002, all citations to exhibits reference original page numbers found in the underlying document, and all emphases have been added.

V. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE OF '830 PATENT

16. After reviewing the materials identified in the List of Exhibits, I have concluded that each of Claims 1-5 **("Challenged Claims")** of the '830 Patent would have been obvious to a person of ordinary skill in the art, based on the following grounds. My opinions in this declaration are consistent with the opinions in my declaration submitted in IPR proceeding, *Samsung Elecs. Co. v. Bishop Display Tech LLC*, IPR2022-00503. The Challenged Claims are obvious for more than one reason and thus my opinions in this declaration may differ from the opinions in my declaration submitted in the prior IPR.

Ground	'830 Patent Claims	Basis for Invalidity
1	1-5	Obvious over Ghanem (Ex. 1004) in view of Nishimura
2	1-2 and 5	Obvious over Tripathi (Ex. 1006) in view of Nishimura

VI. UNDERSTANDING OF THE GOVERNING LAW

A. LEVEL OF ORDINARY SKILL IN THE ART

17. When analyzing a patent, I understand that it is important to identify the relevant art pertaining to the patent as well as the level of ordinary skill in that art at the time of the claimed invention. The "art" is the field of technology to which the patent is related.

18. I have been instructed by counsel that the person of ordinary skill in the art is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor's skill is not determinative of the level of ordinary skill. I further understand that the factors that may be considered in determining the level of skill include: the types of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

B. LEGAL STANDARD FOR CLAIM CONSTRUCTION

19. I understand that the first step in determining whether a patent claim would have been anticipated or obvious is to ascertain how a person of ordinary skill in the art would have understood the claim terms.

20. I have been instructed by counsel on the law regarding claim construction and patent claims, and I understand that a patent may include two types of claims: independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim, or it can further depend from another dependent claim. I understand that a dependent claim includes all the limitations that it recites, in addition to all the limitations recited in the claim(s) from which it depends.

21. It is my understanding that in proceedings before the USPTO, the claims of a patent are to be construed under what is referred to as the "Phillips standard." I understand that this means that claim terms of a patent are given the meaning the terms would have to a person of ordinary skill in the art, in view of the description provided in the patent itself and the patent's file history.

22. I understand that to determine how a person of ordinary skill would understand a claim term, one should look to those sources available that show what a person of skill in the art

would have understood the disputed claim language to mean. I understand that, in construing a claim term, one looks primarily to the intrinsic patent evidence, including the words of the claims themselves, the remainder of the patent, and the patent's prosecution history. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient.

23. I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else. In making this determination, the claims, the remainder of the patent, and the prosecution history are of paramount importance. Additionally, the patent and its prosecution history must be consulted to confirm whether the patentee has acted as its own lexicographer (i.e., provided its own special meaning to any disputed terms), or intentionally disclaimed, disavowed, or surrendered any claim scope.

24. In comparing the claims of the Challenged Patent to the prior art, I have considered the Challenged Patent and its file history in light of the understanding of a person of skill at the time of the alleged invention.

C. OBVIOUSNESS

25. I understand that the prior art may render a patent claim "obvious." I understand that two or more prior art references (e.g., prior art articles, patents, or publications) that each disclose fewer than all elements of a patent claim may nevertheless be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in the art at the time would have been motivated to combine the prior art in such a way. I understand that this motivation to combine need not be explicit in any of the prior art, but may be inferred from the knowledge of one of ordinary skill in the art at the time the patent was filed. I also understand that one of ordinary skill in the art is not an automaton, but is a person

having ordinary creativity. I further understand that one or more prior art references, articles, patents or publications that disclose fewer than all of the elements of a patent claim may render a patent claim obvious if including the missing element would have been obvious to one of skill in the art (e.g., the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system).

26. I understand that under the doctrine of obviousness, a claim may be invalid if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the art to which the subject matter pertains.

27. To assess obviousness, I understand that I am to consider the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and any secondary considerations to the extent they exist.

28. I understand that any evidence of secondary indicia of non-obviousness should be considered when evaluating whether a claimed invention would have been obvious to one of ordinary skill at the time of invention. These secondary indicia of non-obviousness may include, for example:

- a long felt but unmet need in the prior art that was satisfied by the claimed invention;
- commercial success of processes claimed by the patent;
- unexpected results achieved by the invention;
- praise of the invention by others skilled in the art;
- the taking of licenses under the patent by others; and
- deliberate copying of the invention.

I understand that there must be a nexus between any such secondary indicia and the claimed invention.

29. It is also my understanding that there are additional considerations that may be used as further guidance as to when the above factors will result in a finding that a claim is obvious, including the following:

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;
- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;
- the claimed subject matter would have been "obvious to try" choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- there is known work in one field of endeavor that may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to a person of ordinary skill in the art;
- there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims; and
- there is some teaching, suggestion, or motivation in the prior art that would have led a person of ordinary skill in the art to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

30. Finally, I understand that a claim may be deemed invalid for obviousness in light of a single prior art reference, without the need to combine references, if the elements of the claim that are not found in the reference can be supplied by the knowledge or common sense of one of ordinary skill in the relevant art.

VII. OVERVIEW OF THE '830 PATENT

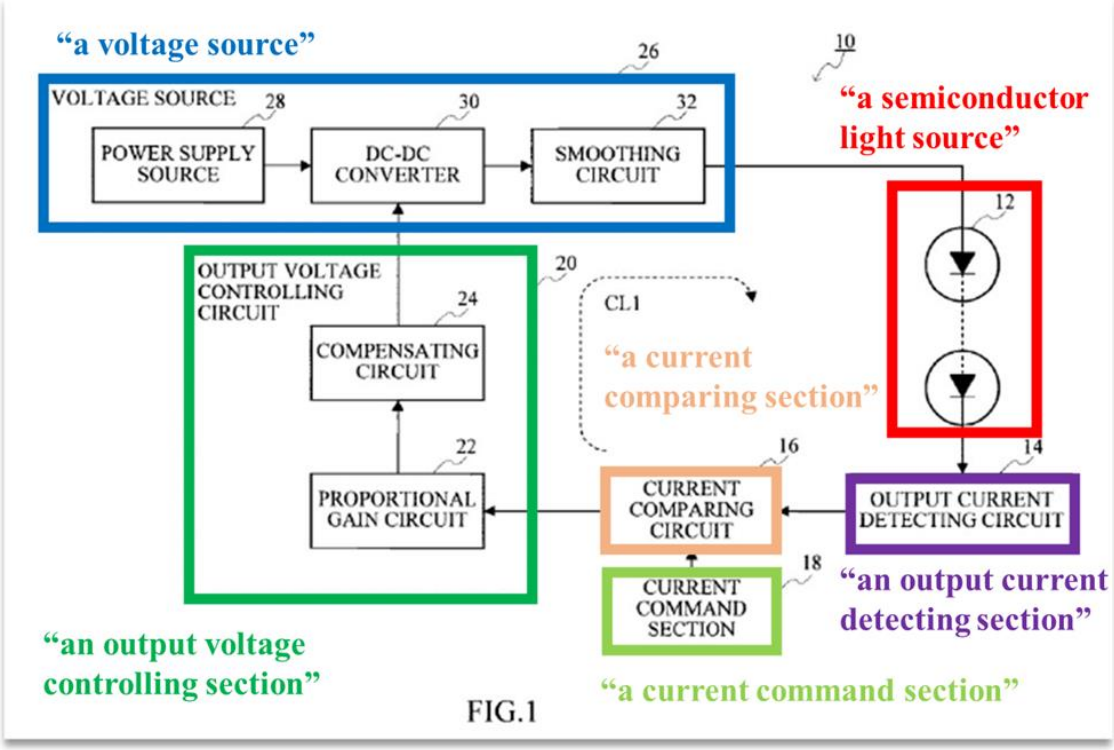
31. I have reviewed U.S. Patent No. 8,093,830 ("the '830 Patent"), which is entitled "Semiconductor Light Source Driving Apparatus and Semiconductor Light Source Driving Method." Ex. 1001.

A. PRIORITY DATE FOR CLAIMS OF THE '830 PATENT

32. I understand that the '830 Patent was filed in the United States on July 1, 2009, and that it was issued on January 10, 2012. The '830 Patent claims priority to an application filed in Japan on July 3, 2008. I understand that, regardless of whether the priority date of the '830 Patent is July 1, 2009 (corresponding to its U.S. filing date) or July 3, 2008 (corresponding to the filing date of the Japanese application), the references I rely on qualify as prior art.

B. THE SUBJECT MATTER OF THE '830 PATENT

33. The '830 Patent discloses that its "object … is to provide a semiconductor light source driving apparatus … that can achieve constant control performance regardless of whether the drive current value is great or small when a drive current value is increased and decreased while light is adjusted." '830 Patent at 4:65-5:3. The '830 Patent includes a description of "Background Art" that was "conventional" and well understood at the time. '830 Patent at 1:20-3:10. The '830 Patent describes that it was known that "[t]he brightness of light emitted by a semiconductor light source depends on the magnitude of the drive current," and "constant-current control makes it possible to control the current applied to semiconductor light sources to be constant against various changes during the control." '830 Patent at 1:25-34. In the context of Figure 1, the '830 Patent depicts and describes "a conventional semiconductor light source driving apparatus that is generally used to perform a constant-current control of a semiconductor light source." '830 Patent at 1:35-38.



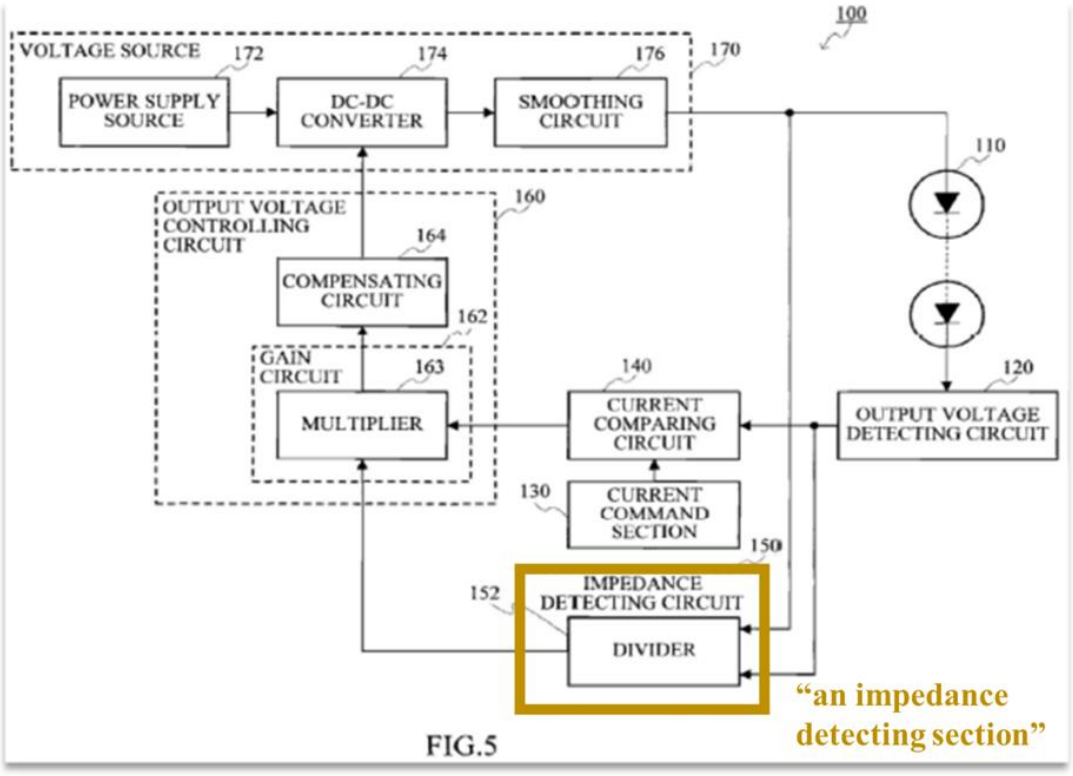
'830 Patent at Figure 1 (annotated).

34. As illustrated in Figure 1 above, "a conventional semiconductor light source driving apparatus" includes a "**semiconductor light source 12**" coupled to a "**voltage source 26**." '830 Patent at 1:39-65. The apparatus also includes an "**output current detecting circuit 14**" that "detects the current applied to this **semiconductor light source 12**." '830 Patent at 1:41-42. The result of the **output current detecting circuit 14** is provided to a "**current comparing circuit 16**," which "compare[s]" the result "with a current command value from **current command section 18**." '830 Patent at 1:39-65. The comparison result is provided to the "**output voltage controlling circuit 20**" to perform a "pulse width control in **voltage source 26** according to the comparison result." '830 Patent at 1:39-65. The '830 Patent describes that this "conventional" apparatus allowed "negative feedback closed loop current control" to be performed, "thereby creating a stable state in **semiconductor light source 12**." '830 Patent at 1:62-65, 2:13-18. The

'830 Patent recognized that the conventional circuit was "not … best employed" for applications requiring a "desired constant current value" to change "frequently." '830 Patent at 2:33:38.

35. The '830 Patent also discloses a second conventional configuration in connection with Figure 2, whereby a second control loop is formed using an "output driving element 42," "voltage comparing circuit 44," "constant current controlling circuit 46," and "resistor (R) 48" that replace the current comparing circuit 16, current command section 18, and output current detecting circuit discussed above in connection with Figure 1. '830 Patent at 2:39-3:3. However, "interference [was] produced between the loops and the operation of the loops" became "unstable," requiring the first control loop to be set to "one-twentieth of the frequency response characteristics of the [second] loop." '830 Patent at 2:63-3:3.

36. To "adjust light of semiconductor light source stably," the '830 Patent proposes an "**[i]mpedance detecting circuit 150**" that "detects the impedance of semiconductor light source 110," and an "output voltage controlling circuit 160" that compensates for the dynamic impedance of the semiconductor light source by multiplying the "impedance characteristics and the gain characteristics (FIGURE 3C) of semiconductor light source 110." '830 Patent at 3:51-53, 7:32-42, 8:62-9:19. Figure 5 of the '830 Patent is described as "an embodiment of the present invention." '830 Patent at 6:1-3.



'830 Patent at Figure 5 (annotated).

37. In view of Figure 1 and the accompanying disclosure, '830 Patent admits that all but the following limitations of claims 1 and 5 were "conventional" and therefore known in the prior art:

- **Claim 1:** "an impedance detecting section that detects an impedance of the semiconductor light source" and "wherein the output voltage controlling section controls the output voltage of the voltage source based on … an output of the impedance detecting section"

- **Claim 5:** "detecting an impedance of the semiconductor light source" and "controlling the output voltage of the voltage source based on … the impedance of the semiconductor light source"

38. The '830 Patent also discloses that the "conventional" driving apparatus I discuss above included a "proportional gain circuit 22." '830 Patent at 1:35-37, 1:63-65. The '830 Patent describes that "a fixed gain is multiplied in proportional gain circuit 22 and output voltage controlling circuit 20 maintains constant gain characteristics regardless of changes in the

impedance of semiconductor light source 12." '830 Patent at 8:5-11. The "gain circuit" concept is recited in claim 3 of the '830 Patent.

39. The '830 Patent also discloses that the "conventional" driving apparatus I discuss above included a "compensating circuit 24." '830 Patent at 1:35-37, 1:63-65.

40. But as I describe in the substantive grounds in this declaration, these limitations were also known in the prior art.

C. THE CHALLENGED CLAIMS OF THE '830 PATENT

41. The Challenged Claims are set forth below. I understand that claims 2-4 depend from claim 1 and therefore include all of the limitations from claim 1. Claim 5 has no dependent claims. In the table below, some of the claim elements have been further sub-divided for ease of reference.

Claim Element	Claim Language from '830 Patent
1(pre)	1. A semiconductor light source driving apparatus comprising:
1(a)	a semiconductor light source that is driven by a current;
1(b)	a voltage source that drives the semiconductor light source;
1(c)	an output voltage controlling section that controls a drive current value for driving the semiconductor light source by controlling an output voltage of the voltage source;
1(d)	an output current detecting section that detects an output current of the semiconductor light source;
1(e)	a current command section that specifies a reference value of a drive current which is applied to the semiconductor light source;

Claim Element	Claim Language from ’830 Patent
1(f)	a current comparing section that compares the output current detected by the output current detecting section and the reference value specified by the current command section; and
1(g)	an impedance detecting section that detects an impedance of the semiconductor light source,
1(h)	wherein the output voltage controlling section controls the output voltage of the voltage source based on an output of the current comparing section and an output of the impedance detecting section.
2	2. The semiconductor light source driving apparatus according to claim 1, wherein the impedance detecting section comprises a divider that divides the output voltage of the voltage source by the output current detected by the output current detecting section, and acquires a value corresponding to the impedance of the semiconductor light source from an output of the divider.
3	3. The semiconductor light source driving apparatus according to claim 1, wherein: the output voltage controlling section comprises a gain circuit that sets a gain; and the gain circuit multiplies the impedance of the semiconductor light source detected by the impedance detecting section and the output of the current comparing section to prevent a gain of a control loop from changing even when the impedance of the semiconductor light source changes.
4	4. The semiconductor light source driving apparatus according to claim 1, wherein the output voltage controlling section comprises: a multiplier that multiplies the impedance of the semiconductor light source detected by the impedance detecting section and the output of the current comparing section; and a compensator that performs predetermined processing with respect to an output of the multiplier to compensate for control characteristics.
5(pre)	5. A semiconductor light source driving method in a semiconductor light source driving apparatus that comprises:
5(a)	a semiconductor light source that is driven by a current;

Claim Element	Claim Language from ’830 Patent
5(b)	a voltage source that drives the semiconductor light source; and
5(c)	an output voltage controlling section that controls a drive current value for driving the semiconductor light source by controlling an output voltage of the voltage source,
5(d)	the semiconductor light source driving method comprising: detecting an output current of the semiconductor light source;
5(e)	comparing the detected output current of the semiconductor light source and a specified reference value;
5(f)	detecting an impedance of the semiconductor light source; and
5(g)	controlling the output voltage of the voltage source based on a result of the comparison and the impedance of the semiconductor light source.

D. COMPARISON OF CLAIM 1 TO CLAIM 5 OF THE ’830 PATENT

42. ’830 Patent claims 1 and 5, the two independent claims, are similar to one another, except that claim 1 adds “a current command section that specifies a reference value of a drive current which is applied to the semiconductor light source.” All limitations of claim 5 are already subsumed within claim 1. The following table correlates Claim 5 with Claim 1:

Limitation	**Text**	**Cross-Cite to Claim 1**
5(pre)	“A semiconductor light source driving method in a semiconductor light source driving apparatus that comprises:”	1(pre)
5(a)	“a semiconductor light source that is driven by a current;”	1(a)
5(b)	“a voltage source that drives the semiconductor light source; and”	1(b)

5(c)	"an output voltage controlling section that controls a drive current value for driving the semiconductor light source by controlling an output voltage of the voltage source,"	1(c)
5(d)	"the semiconductor light source driving method comprising: detecting an output current of the semiconductor light source;"	1(d)
5(e)	"comparing the detected output current of the semiconductor light source and a specified reference value;"	1(e) and 1(f)
5(f)	"detecting an impedance of the semiconductor light source; and"	1(g)
5(g)	"controlling the output voltage of the voltage source based on a result of the comparison and the impedance of the semiconductor light source."	1(h)

E. PROSECUTION HISTORY OF THE '830 PATENT

43. The '830 Patent was filed on July 1, 2009 as Application No. 12/496,472. The USPTO examiner did not issue any office actions during prosecution. Ex. 1002 at 152.

44. The claims were allowed on Oct. 31, 2011. Ex. 1002 at 150. In the Notice of Allowance, the Examiner stated in their reasons for allowance that:

> [T]he best prior art of record, Suzuki, taken alone or in combination of other references, does not teach or fairly suggest a method or a semiconductor light source driving apparatus comprising, among other things, an impedance detecting section that detects an impedance of the semiconductor light source, wherein the output voltage controlling section controls the output voltage of the voltage source based on an output of the current comparing section and an output of the impedance detecting section (claim 1); and detecting an impedance of the semiconductor light source; and controlling the

> output voltage of the voltage source based on a result of the comparison and the impedance of the semiconductor light source (claim 5), as set forth in the claims.

Ex. 1002 ('830 Patent File History, 10/31/2011 Notice of Allowance) at 155.

VIII. LEVEL OF ORDINARY SKILL IN THE ART FOR THE '830 PATENT

45. In the 2008-2009 timeframe, at the time the Challenged Patent was filed, I believe that a relevant person of ordinary skill in the art would have had an undergraduate degree in electrical engineering (or equivalent subject) together with two or three years of experience in designing circuits for driving light-emitting devices including organic light-emitting diodes, or a Ph.D. with experience in the same. This description is approximate, and a higher level of education or skill might make up for less experience, and vice-versa.

46. I would have qualified as a person of ordinary skill in the art at least as of the earliest possible claimed priority date of the '830 Patent (July 3, 2008, the Japanese priority date), and that I have a sufficient level of knowledge, experience, and education to provide an opinion in the field of the Challenged Patent. I am familiar with what a person of ordinary skill in the art knew at that time because of my lengthy experience with engineering subjects of a similar nature to the concepts presented in the Challenged Patent. Additionally, at that time, I was familiar with the general subject material in the cited prior art in this Declaration.

IX. CLAIM CONSTRUCTION

47. In my opinion, and for the purposes of this declaration, I apply the ordinary and customary meaning of the claim terms of the Challenged Patent.

X. TECHNOLOGY BACKGROUND AND STATE OF THE ART FOR THE '830 PATENT

48. In the subsections below, I describe some of the basic principles of electrical engineering that would have been well-known to a person of ordinary skill in the art by at least 2008 (and long before).

A. EXEMPLARY REFERENCES CORROBORATING THE GENERAL ENGINEERING KNOWLEDGE

a. Horowitz Handbook (Ex. 1009)

49. As an example of general electrical engineering knowledge regarding circuit design, Exhibit 1009 ("Horowitz Handbook") is a textbook published in 1989 entitled "The Art of Electronics," and authored by Paul Horowitz et al. This textbook covers electronics and is intended as a reference book and an electronic circuit design textbook. I have relied on this textbook throughout my career as an electrical engineer as a reference when designing circuits.

b. Warwick Text (Ex. 1010)

50. As a further example of general electrical engineering knowledge, Exhibit 1010 ("Warwick Text") is a textbook published in 1996 entitled "An Introduction to Control Systems," and authored by Kevin Warwick. This college-level textbook introduces the theory and practice of control systems engineering to students. Warwick Text Section *xi*.

c. Winder Text (Ex. 1011)

51. As an example of power supply design knowledge, Exhibit 1011 ("Winder Text") is a textbook published in 2008 entitled "Power Supplies for LED Driving," and authored by Steve Winder. This textbook covers the design of power supplies specifically for driving light-emitting diodes.

d. Franco Text (Ex. 1014)

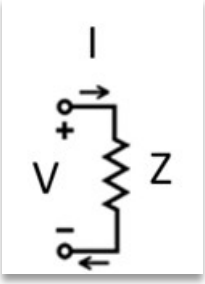
52. As an example of analog integrated circuit knowledge, Exhibit 1014 ("Franco Text") is a textbook published in 2002 entitled "Design with Operational Amplifiers and Analog Integrated Circuits," and authored by Sergio Franco. This textbook covers the design of analog circuits including current-to-voltage and voltage-to-current converters as well as analog multipliers and dividers.

B. CURRENT, VOLTAGE, IMPEDANCE, AND OHM'S LAW

53. Electricity is a form of energy characterized by the movement of charged particles (e.g. electrons) in materials such as metals. A detailed understanding of electricity is the foundation of any electrical engineering education program as it applies to almost all aspects of electrical engineering.

54. Electricity is characterized by three parameters:

- Voltage (V): a measure of electrical potential energy
- Current (I): a measure of electron flow rate
- Impedance (resistance)[1] (Z): a measure of the opposition to electrical flow



55. To understand the concept, electricity has often been analogized to water flow in a pipe system. Each of these three parameters is analogous to parts of a water pipe system. In the

[1] Impedance and resistance describe the same concept, opposition to electrical current. Impedance is generally used with respect to alternating-current systems to address both the real and complex components of alternating current, whereas resistance is generally related to direct-current systems. With direct current, there is no complex component and the real component is just resistance, so they can be used interchangeably for direct current.

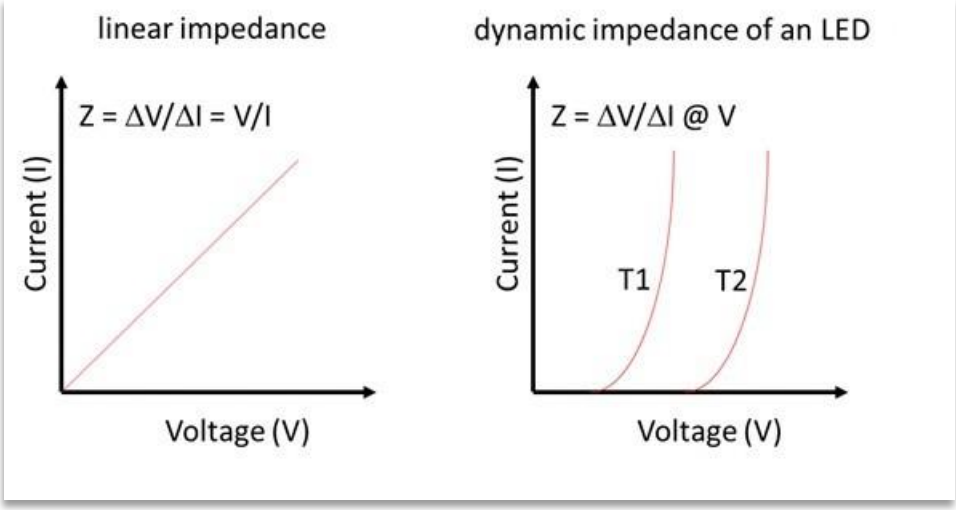
water analogy, a pump introduces a pressure (voltage) to the water. The flow rate (current) of the water is dependent on the amount of pressure and the characteristics of the pipe (impedance), such as pipe diameter and other obstructions, such as sand.

56. Perhaps the most basic and well-known equation to electrical engineers is Ohm's law, which relates current, voltage, and impedance.

$$V\ (volts) = I\ (amperes)\ x\ Z\ (ohms)$$

It was well-known prior to 2008 that for a material such as metal, impedance is ideally linear, meaning that its impedance is constant and the ratio of *V*/*I* is fixed. It was also well-known that semiconductor devices, such as light-emitting diodes ("LEDs"), typically have non-linear impedance. Winder Text at Section 2.4.

57. It was well-known known prior to 2008 that LEDs are semiconductor-based devices that convert electrical energy into optical energy. It was also well-known that for LEDs, the impedance changes depending on many factors, including the applied voltage and temperature. The figure below compares a linear impedance with a dynamic impedance, such as that known in an LED. In the figure below, temperature T1 is greater than temperature T2, and the figure demonstrates how the voltage/current characteristics of the LED change with temperature. Ex. 1011 (Winder Text) at Sections 2.4, 3.1. Furthermore, it was known that manufacturing variations also affect the impedance of LEDs.



58. It was well-known that LEDs need to be driven at a constant current to maintain constant brightness. Winder Text Section 1.0. Due to the dynamic impedance of LEDs, control systems have been required to ensure that a constant (fixed) current flows through the LEDs to yield constant brightness. Ex. 1011 (Winder Text) at Section 2.1, 3.1-3.3. Therefore, power supplies for driving LEDs have required control systems to generate a constant current by actively adjusting the voltage in the face of the changing impedance. A person of ordinary skill in the art would have been well aware of the dynamic impedance of LEDs and that it is affected by operating voltage and temperature. Said person of ordinary skill in the art would have also been aware that a constant current flow through the LEDs is required to ensure constant brightness.

C. FEEDBACK CONTROL

59. At a high level, control systems have been used to control the output of a system. A system operates on an input signal in order to provide an output signal, as shown below.

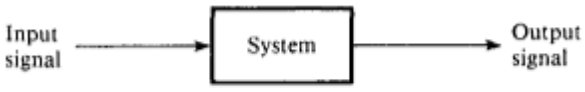


Fig. 1.2 Basic system schematic

Ex. 1010 (Warwick Text) at Section 1.1.

60. It was known that there are two basic control systems: open-loop and closed-loop (or feedback control). Open-loop systems send an input command directly to a controller as in Figure 1.2 above. One example is that of a water heater as shown below.

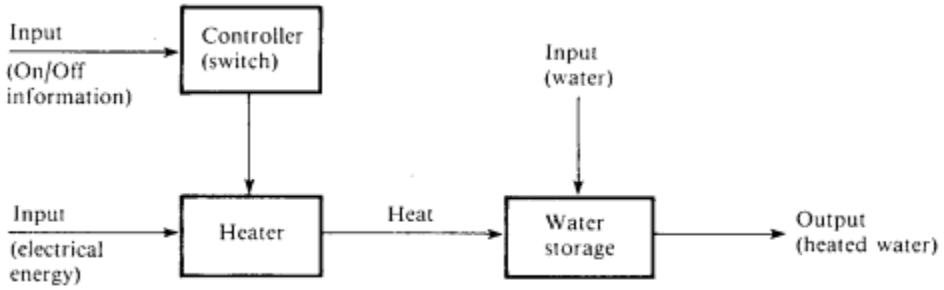


Fig. 1.4 Water heating device

Ex. 1010 (Warwick Text) at Figure 1.4.

> A problem with this open-loop system is that although today the water may be provided at a nice temperature at the output, tomorrow this might not be the case. Reasons for this could be a change in ambient conditions, a change in the temperature or amount of water input to the storage dev ice or a drop in the voltage used to supply the heater. Merely leaving the system as it is and hoping for the best is clearly not satisfactory in the majority of cases. It would be much more sensible to measure the temperature of the heated water such that the on/off information can be varied appropriately in order to keep the output at approximately the temperature desired. We have now closed the loop, by providing feedback from the system to output to an input, hence the system is no longer open-loop, but rather is closed-loop.

Ex. 1010 (Warwick Text) at Section 1.3. An open-loop system does not have the ability to control for disturbances such as changes in ambient temperature or the amount of water.

61. On the other hand, feedback control is shown below, which includes a feedback path. It was well-known that when implementing feedback control, an output signal or parameter is measured and then compared with an input or reference to adjust the output signal, as shown below. Warwick Text at Section 1.4.

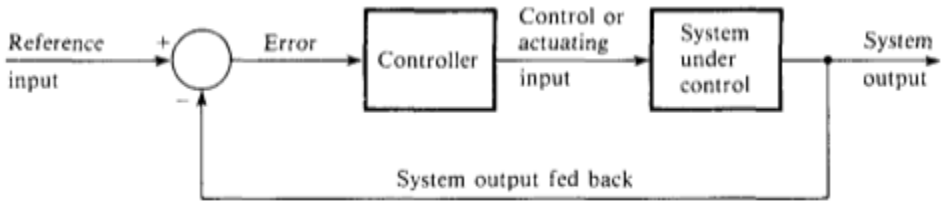


Fig. 1.5 Closed-loop system

Warwick Text at Figure 1.5.

> The open-loop heating system of Figure 1.4 can be converted into a closed-loop system by measuring the temperature of the heated water (output) and feeding this measurement back such that it affects the controller by means of modifying the switch on/off information. It is then apparent that when variations in performance occur due to system modifications or a change in ambient conditions, the effect on the system output will be much reduced because of the feedback arrangement, i.e. with feedback the system is less sensitive to variations in conditions. Let us assume that we require the water temperature to be 50°C. With the system in open-loop, a variation in system characteristics would merely cause the temperature to drift away from the required value. With the system in closed-loop however, any variation from 50°C will be seen as an error when the actual measured temperature is compared with the required value, and the controller can then modify the control input in order to reduce the error to zero.

Warwick Text at Section 1.4.

62. An additional concept is that of gain. Gain is the proportional value (multiplier) that characterizes the magnitude of the input versus the magnitude of the output. Feedback control allows for correction of the output signal by measuring the output, comparing it to an input or reference signal, and then modifying the gain. Warwick Text at Section 3.4.4.

63. It was known that a feedback control is dynamic in that it undergoes a transient response before reaching a steady-state that more closely matches the input. If the value of the gain is too large, a correction may occur too quickly, causing the signal to overshoot. If the value of the gain is too small, the transient response may be longer, causing delays as shown below.

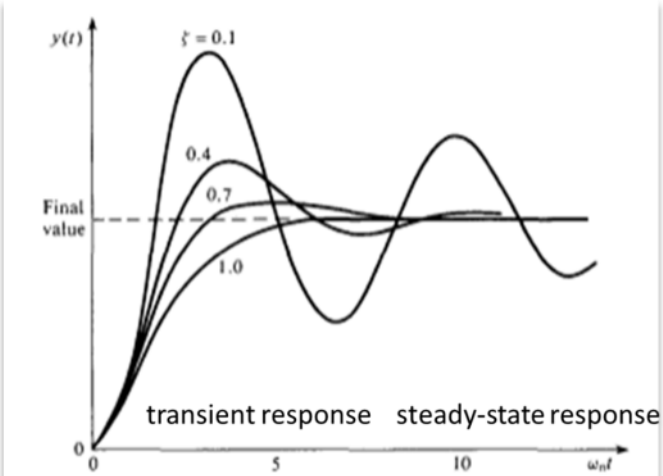


Fig. 3.10 Variation of transient response with damping ratio

Warwick Text at Figure 3.10. As shown, a known tradeoff exists. If a high gain is selected, the chance of overshooting increases, whereas with a low gain the response time is slower. A person of ordinary skill in the art would have understood this tradeoff in making design choices for LED current control systems.

D. CIRCUITS

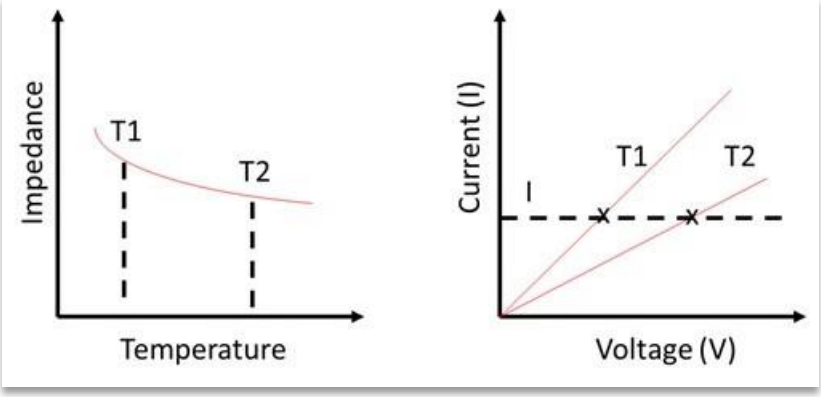
a. Sensors

64. It was well-known that analog sensors are devices that generate outputs (e.g., voltage outputs) that correspond to a physical quantity to be measured. Such a sensor can be used to measure the output of a feedback control system.

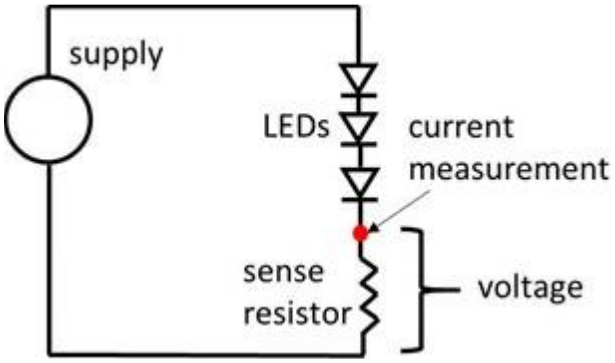
65. For example, a thermistor is a resistor that changes its impedance based on temperature. Therefore, a signal representative of the temperature can be measured by dividing the voltage by the current. As shown in the image below for a representative thermistor, temperature

T2 is greater than temperature T1, and as shown the impedance at T1 is greater than the impedance at T2. When driven by a fixed current, the measured voltage indicates the temperature.

66. With respect to LEDs, it was well-known that the current flowing is generally



measured or sensed via a "current sense" resistor. In this case, a "sense resistor" is placed in series with the LEDs, and the current flowing through the LEDs and the sense resistor establishes a voltage across the sense resistor as shown below. Ex. 1011 (Winder Text) at Section 3.1.2.



This measured voltage represents the current flowing through the LEDs and the voltage signal that is generated can be used in feedback control. It was well-known that as this current sense resistor is in series with the LEDs, it is generally selected to be a small value so as not to cause a large dissipation of power.

67. It should be noted that the '830 Patent offers this as one of two specific methods for determining the current. *See* '830 Patent at 7:9-13 ("Output current detecting circuit 120 detects the drive current (i.e. output current) that is applied to semiconductor light source 110. The output

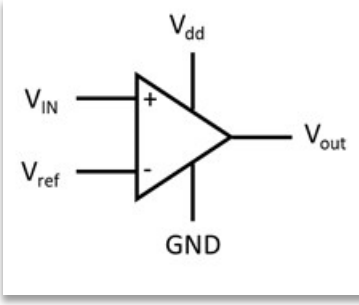
current detecting circuit may employ a method of detecting the voltage generated across a resistor (see FIGURE 2) or a non- contact scheme using a Hall element.").

68. A person of ordinary skill in the art would have been aware of this means of detecting a current value and would be able to implement it to design circuits.

b. <u>Comparators</u>

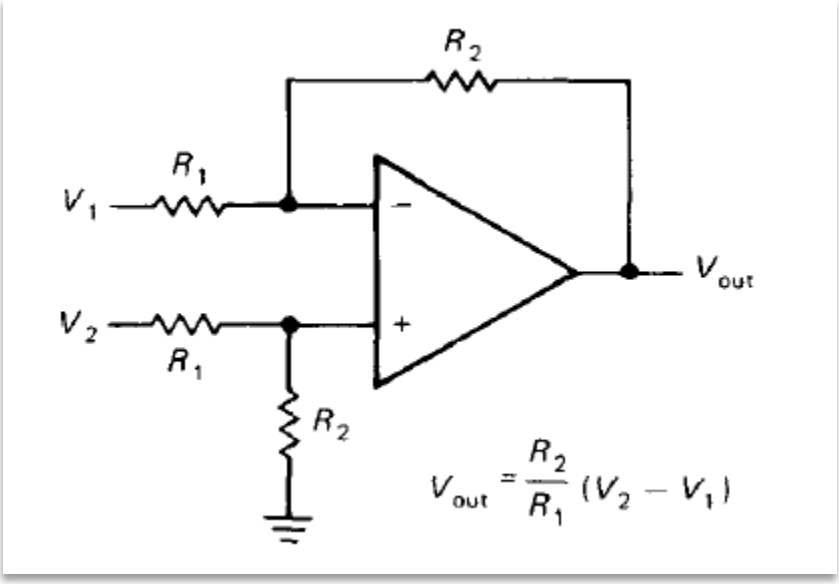
69. It was well-known that a comparator is a circuit that compares two values and generates an output based on this comparison. In a feedback control system, an output measurement, such as LED current, is fed back and compared to an input or reference. Warwick Text at Figure 1.5.

70. Perhaps the simplest implementation of this function is via a comparator integrated circuit. In this implementation, a binary (high/low) output is generated based on a comparison of two input signals. In this example, when V_{in} is less than V_{ref}, a low output (~ 0 V or ground) is generated and, when V_{IN} is greater than V_{ref}, a high output (~V_{dd}) is generated as shown below. Horowitz Handbook at Section 4.23.



Condition	Output
$V_{in} < V_{ref}$	V_{out} = GND (logic low)
$V_{in} > V_{ref}$	$V_{out} = V_{dd}$ (logic high)

71. Another type of comparison may be achieved by means of a difference amplifier. It was known that a difference amplifier measured the difference in two signals by subtracting their values. Horowitz Handbook at Section 4.2.4.



Ex. 1009 (Horowitz Handbook) at Figure 418. A person of ordinary skill in the art would have been aware of this means of comparing signals either to produce a binary result or a measure of the difference in the signals and would be able to implement it to design circuits.

c. <u>Multipliers and Dividers</u>

72. It was well-known that a multiplier can be used to generate an output representative of the product of two analog voltage signals. *See* Franco Text at p. 615. Multipliers can be created out of discrete components such as transistors but were also available as integrated circuits. One example is the AD534 analog multiplier from Analog Devices. *See* Franco Text at p. 618.

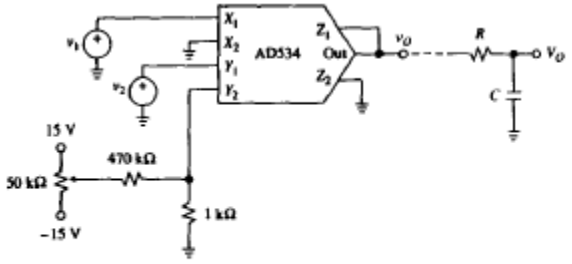


FIGURE 13.10
Basic multiplier connection for $v_O = v_1 v_2/10$. If followed by a low-pass filter, it can be used for phase detection.

Ex. 1014 (Franco Text) at Figure 13.10.

73. It was similarly well-known that such an integrated circuit (e.g. AD534) could be wired to perform division of two analog voltages. *See* Franco Text at p. 619.

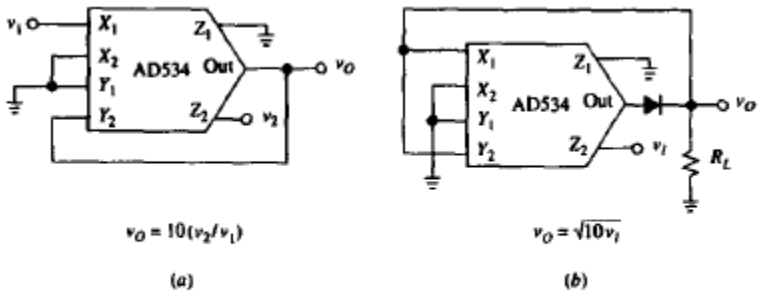


FIGURE 13.11
Analog divider and square-rooter.

Ex. 1014 (Franco Text) at Figure 13.11.

74. A person of ordinary skill in the art would have been aware of such analog circuitry for multiplying or dividing two analog voltages.

E. LED DRIVER CIRCUITS

75. It was well-known that the resistance of an LED is dynamic in that it will change based on the applied voltage and temperature changes. Ex. 1011 (Winder Text) at Section 3.1. It was further well-known that the resistance of an LED is dynamic and changes, yet it was also known that in order to ensure constant brightness, the LEDs need to be driven by a constant current. Thus, based on simple Ohm's law, it was known that if the current must stay constant and the impedance changes, then the voltage must be actively changed during operation to keep the current and intensity of the light output constant. Winder Text at Section 3.5.

76. Therefore, it was known that circuits for driving LED drivers are generally designed to actively control the voltage based on feedback. At its most basic, a measurement of the output current is made and this signal is used to modify the input voltage.

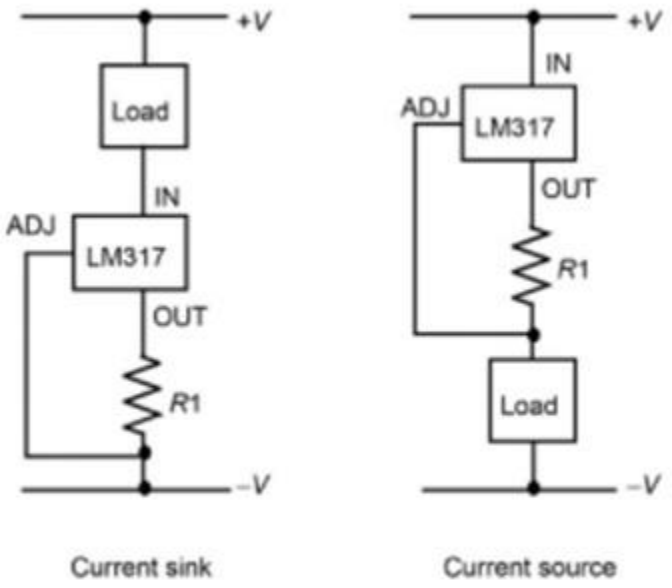
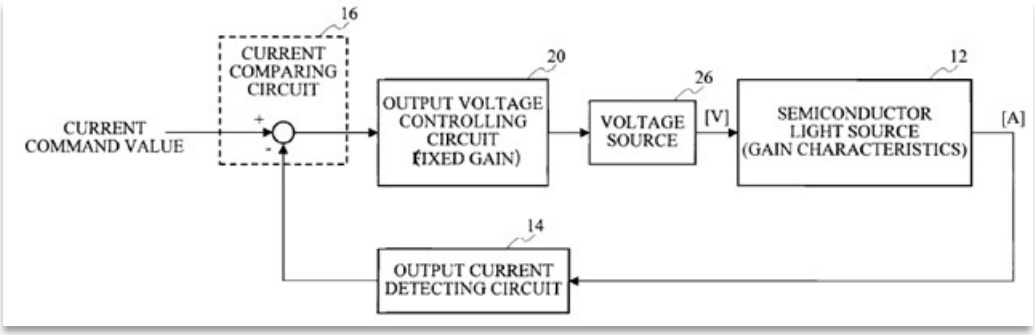


FIGURE 4.3 Constant Current Circuits Using LM317.

Winder Text at Figure 4.3. In this example, current sense is accomplished via a "current sense" resistor R1. This signal is used in feedback to control a voltage regulator, which controls the current applied to the load (LEDs).

77. The '830 Patent discloses the same means of control in the background section. The '830 Patent at Figure 4 shows "a block diagram obtained by modeling" the "conventional semiconductor light source driving apparatus 10 shown in FIGURE 1." '830 Patent at 3:61-62. The '830 Patent illustrates a conventional control system used for controlling the current delivered to LEDs based on the output current as a feedback signal, as shown below.



'830 Patent at Figure 4.

78. According to the '830 Patent, in this conventional circuit, the result of the output current is subtracted from the current command value (input value) to find the difference. The difference is then multiplied by a gain to control the voltage source and thus control the amount of current delivered to the LEDs.

> When a voltage is supplied to semiconductor light source 12 from voltage source 26, a drive current that match the characteristics of semiconductor light source 12 is applied to semiconductor light source 12 and so this drive current is used as an output of semiconductor light source 12. This drive current is detected by output current detecting circuit 14. This detection result is outputted to current comparing circuit 16 and is subtracted from the current command value to find the difference. Output voltage controlling circuit 20 multiplies this difference by a certain gain to control voltage source 26. According to such a control loop, the output current from semiconductor light source 12 is controlled to match with the current command value.

'830 Patent at 3:63-4:8. A person of ordinary skill in the art would have been aware that various output signals could be used in feedback in order to tailor the control of LEDs.

XI. GROUNDS OF UNPATENTABILITY

A. GROUND 1: GHANEM IN VIEW OF NISHIMURA

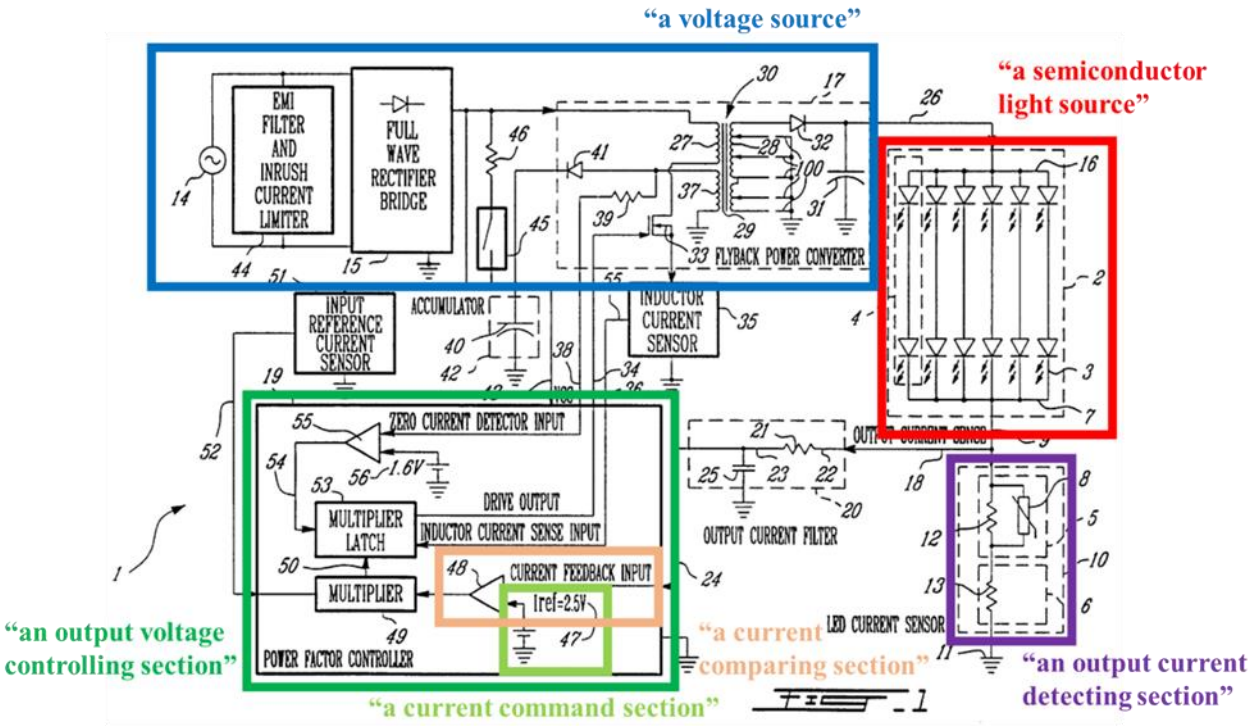
a. Status of Ghanem as Prior Art

79. "Ghanem" refers to United States Patent No. 6,285,139, entitled "Non-Linear Light-Emitting Load Current Control" and naming Mohamed Sherif Ghanem as the sole inventor. Ghanem was filed in the United States on December 23, 1999 and issued on September 4, 2001. Thus, Ghanem issued in the United States more than one year before the '830 Patent was filed in the United States (July 1, 2009). Accordingly, I understand that Ghanem qualifies as prior art to the '830 Patent.

b. Overview of Ghanem

80. Similar to the '830 Patent, Ghanem is directed to an "electronic circuit" that includes "LEDs … driven by a constant current." Ghanem at 1:39-2:53, 3:36-39, 4:40-44, 5:23-25. The circuit uses a "current sensor circuit and a power supply system" to "adjust the dc voltage and current [supplied to LEDs] to … keep the light intensity produced by the light source substantially constant." Ghanem at 1:39-2:53, 3:36-39, 4:40-44, 5:23-25.

81. For example, Ghanem discloses an "electronic circuit of a light-emitting-diode lamp" that incorporates a "current sensor circuit and power supply system" to "perform variable current feedback control" for a "**set 2 of light-emitting diodes 3**." Ghanem at 3:36-39, 3:61-67, 4:26-35. The disclosed electronic circuit includes "**a controllable dc voltage and current source**" that powers the LEDs. Ghanem at 2:33-39, 3:11-26, 4:30-35. A "**current sensor circuit 10**" detects the "total current flowing through the set 2 of **light-emitting diodes 3**." Ghanem at Abstract, 4:13-21, 5:48-52, 6:34-38. The **current sensor circuit 10** provides a "current-representative voltage signal" to a "**comparator 48**," where the "current-representative voltage signal" is compared to a "**fixed reference current I_{ref} (47)**" from a **coupled voltage source** and provides a result. Ghanem at Abstract, 4:13-21, 5:48-52, 6:34-38. The comparison output of **comparator 48** is provided to a "**power factor controller 19**," which "perform[s] variable current feedback control" to "effectively control[]" the output of the **controllable dc voltage and current source**. Ghanem at 4:25-35, 6:30-7:23. Therefore, the circuit "maintains a roughly constant power output from the LEDs" to "keep the light intensity produced by the light source [**light-emitting diodes 3**] substantially constant." Ghanem at 2:47-54, 5:53-56.



Ghanem at Figure 1 (annotated).

c. Status of Nishimura as Prior Art

82. "Nishimura" refers to United States Patent No. 7,332,699, entitled "Feed-Forward Methods and Apparatus for Setting the Light Intensities of One or More LEDs" and naming Ken A. Nishimura as the sole inventor. Nishimura was filed in the United States on July 23, 2004, published in the United States as publication no. 2006/0016959 on January 26, 2006, and issued in the United States on February 19, 2008. Thus, Nishimura published and issued in the United States more than one year before the '830 Patent was filed in the United States (July 1, 2009). Accordingly, I understand that Nishimura qualifies as prior art to the '830 Patent.

d. Overview of Nishimura

83. Similar to the '830 Patent, Nishimura discloses an LED drive circuit that "set[s] the light intensity of … LED[s]" to compensate for "[t]emperature, aging and other factors [that] can lead to a shift in the intensity of light emitted by a light emitting diode." Nishimura at 1:7-23, 1:27-

31. Nishimura recognizes that "[i]t is known that the voltage at which an LED starts to conduct appreciable current (i.e., its turn-on voltage), as well as the LED's dynamic impedance, are functions of the LED's junction temperature and aging effects." Nishimura at 2:22-25.

84. Nishimura discloses "controlling the LED's operating current and, as a consequence, the LED's light intensity." Nishimura at 2:12-15. For example, Nishimura discloses a "**current sensor** to measure an operating current," a "**voltage sensor** to measure a voltage," and "**control circuitry 506**" that "estimate[s] a dynamic impedance of the LED[s]" using "acquired readings from [the] current and voltage sensors. Nishimura at 2:64-3:5, 4:48-58, Claims 18, 24. For example, Nishimura discloses estimating a dynamic impedance of the LED by using the acquired reading to divide voltage by current, yielding an impedance. Nishimura at 2:64-3:5. Specifically, the "current sensor 502 measures the operating current supplied to the LED 402" and the "voltage sensor 504 measures a voltage of the LED 402." Nishimura at 4:51-54. The estimated impedance is then used by the **control circuitry 506** to "set the desired light intensities of the LEDs." Nishimura at Claims 18, 24. Therefore, the current sensor 502, voltage sensor 504, and control circuitry 506 jointly disclose an impedance detecting section.

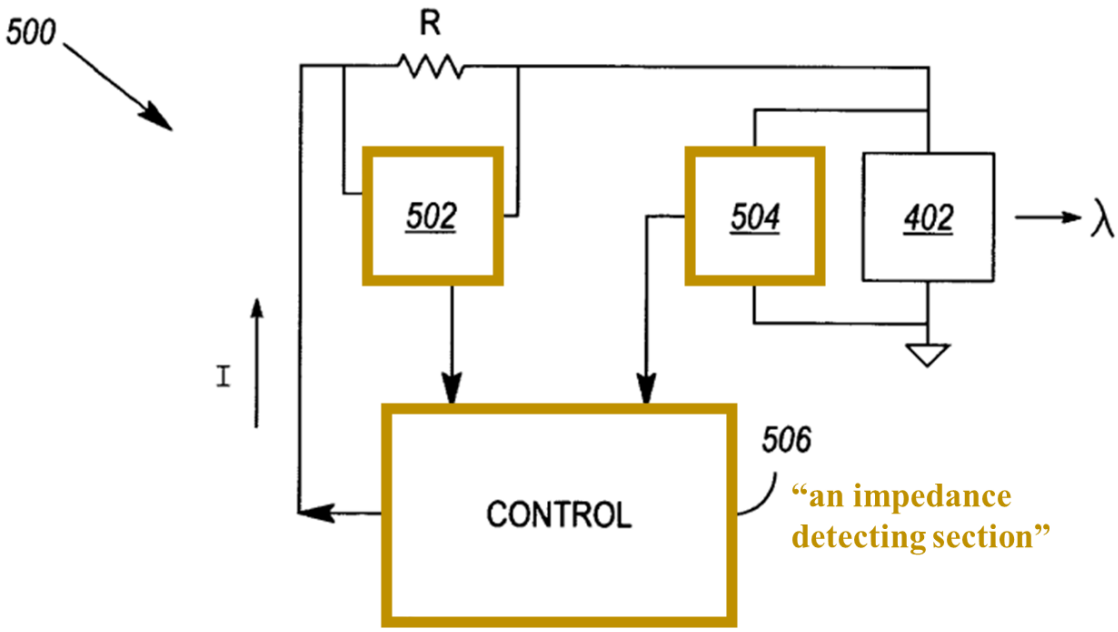


FIG. 5

Nishimura at Figure 5 (annotated).

e. Motivation to Apply Nishimura's Teachings to Ghanem

85. Ghanem and Nishimura are in the same field as the '830 Patent and pertinent to the problems addressed by the '830 Patent. For example, the '830 Patent's field includes LED driving circuits and the '830 Patent purports to address the problem of controlling LED light intensity. '830 Patent at 1:16-18 ("The technical field relates to a semiconductor light source driving apparatus and semiconductor light source driving method that are suitable for display devices."), 3:16-20 ("However, with the technique disclosed in Patent Literature 1, the response upon stable operation depends on the response of the slower control loop, and, therefore, the response upon light adjustment depends on the response of the slower control loop."), 3:47-54 ("Accordingly, in constant-current control according to a conventional control loop, it is difficult to maintain constant control characteristics because the control loop round trip gain ('control loop gain' or

simply 'loop gain') changes depending on the value of the voltage that is applied to an element. That is, it is difficult with conventional constant-current control to adjust light of a semiconductor light source stably."), 4:32-5:3 ("That is to say, seen from the power supply side, the impedance of a semiconductor light source generally changes according to the drive current value … there is a problem that, due to the electrical characteristics of the semiconductor light source, the control loop gain changes depending on whether the drive current value is great or small, thereby changing current control performance … The object is to provide a semiconductor light source driving apparatus and semiconductor light source driving method that can achieve constant control performance regardless of whether the drive current value is great or small when a drive current value is increased and decreased while light is adjusted."), 5:45-50 ("The semiconductor light source driving apparatus and semiconductor light source driving method according to the present invention can achieve constant control performance regardless of whether a drive current value is great or small when the drive current value is increased and decreased while light is adjusted.").

86. Ghanem's field includes LED driving circuits as well, and Ghanem is pertinent to the problem of controlling LED light intensity. Ghanem at 1:6-10 ("The present invention relates to a temperature-dependent current sensor circuit and a substantially constant intensity light source and corresponding method using this sensor circuit."), 1:55-2:3 ("Since voltage feedback control of the supply of a light-emitting diode is not desirable, current feedback control is required to ensure durability of the light-emitting diode. Also, a fixed LED output current presents the following drawbacks: at higher temperature the output LED power decreases; and at lower temperature the output LED power increases … Another object of the present invention is to regulate the output power, hence the light intensity, of a non-linear light-emitting load.").

87. Nishimura's field also includes LED driving circuits, and it is pertinent to the problem of controlling LED light intensity. Nishimura at 1:7-23 ("Temperature, aging and other factors can lead to a shift in the intensity of light emitted by a light emitting diode (LED). When a light source is formed from a plurality of LEDs, shifts in the intensities of the light source's individual LEDs can lead to a shift in the light source's color point … discloses how to 1) measure the spectral content of an LED light source using one or more photosensors, and then 2) alter the operating current(s) of one or more of the light source's LEDs in response to the measured spectral content, to thereby maintain the light source's color point."), 1:27-31 ("In one embodiment, an operating current of an LED is varied and, at one or more values of the operating current, a corresponding voltage of the LED is measured. The measured voltages are then used as feed-forward variables to set the light intensity of the LED."), 2:7-21 ("A shift in the intensity of light emitted by an LED may be precipitated by factors such as a change in temperature of the LED's junction, or aging effects. Previously, these shifts have been accounted for by using a photosensor to sense the LED's light, and then regulating the LED's operating current in response to the sensed light … there are times when implementing the photosensor required to sense the LED's light is just too costly, too complex, or impractical to implement.").

88. A person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings to Ghanem's LED driver circuit. Such an implementation would have advantageously enhanced the reliability of the circuit by "closely predict[ing] the intensity of light emitted by an LED as a function of … operating current" that "can then be used to set the light intensity of an LED." Nishimura at 2:22-34. Nishimura discloses a direct impedance measurement whereby the dynamic impedance is estimated by measuring the voltage across and the current applied to the LEDs. Nishimura at 4:54-58, Claim 18, 24, Figure 5.

Thus, Nishimura teaches that the voltage and current characteristics are read directly from the LEDs.

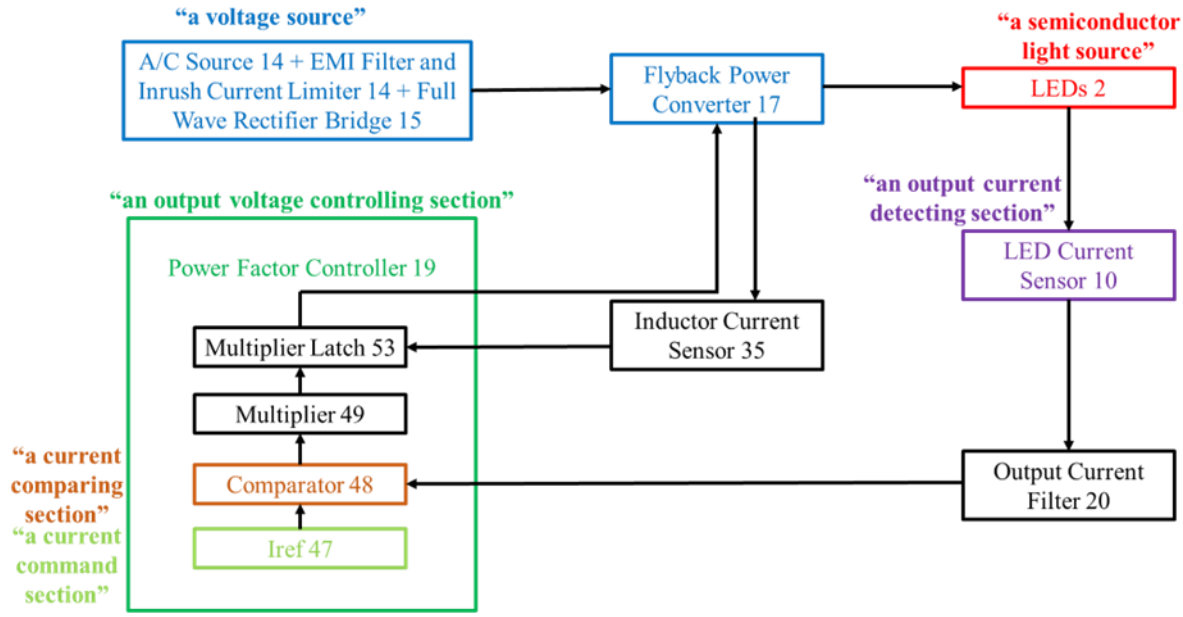
89. On the other hand, Ghanem discloses a thermistor as a "simple-low cost circuit" for "[c]urrent feedback control" of a "non-linear load." Ghanem at 2:25-32. A person of ordinary skill in the art would have recognized that the thermistor of Ghanem is an indirect analog for the dynamic impedance of the LEDs because it is a separate element from the LEDs themselves. For example, Ghanem discloses a thermistor that adjusts its impedance in response to temperature, but it is a separate component from the LEDs and therefore would not have the same impedance characteristics as an LED.

90. A person of ordinary skill in the art would have understood that the direct impedance measurement of Nishimura would more accurately account for the dynamic impedance of the LEDs, as compared to the indirect impedance compensation of the thermistor of Ghanem, as it directly measures the voltage and current characteristics of the LEDs instead of using a separate element to estimate such characteristics. Indeed, Ghanem recognizes the need to consider changes in current and impedance when regulating LED brightness. Ghanem at Abstract, 2:54-3:3, 4:13-22. Thus, applying Nishimura's impedance detection teachings in implementing Ghanem's LED driver circuit would have furthered Ghanem's objective of regulating output power to the LEDs to maintain a brightness, including based on current and impedance changes, and would have done this more accurately compared to the thermistor solution proposed in Ghanem.

91. Further, such an implementation would have advantageously enhanced the reliability of the system by regulating the output power and setting the proper light intensity of the LEDs based on two feedback factors (load current through the LEDs and dynamic impedance of

the LEDs), instead of just one factor (load current). Implementing Ghanem's LED driver circuit to account for a detected impedance, as taught by Nishimura, would be nothing more than applying a known technique of impedance detection to a known device ready for improvement to yield predictable results of accounting for junction temperature and aging effects in addition to load current when setting a light intensity of LEDs.

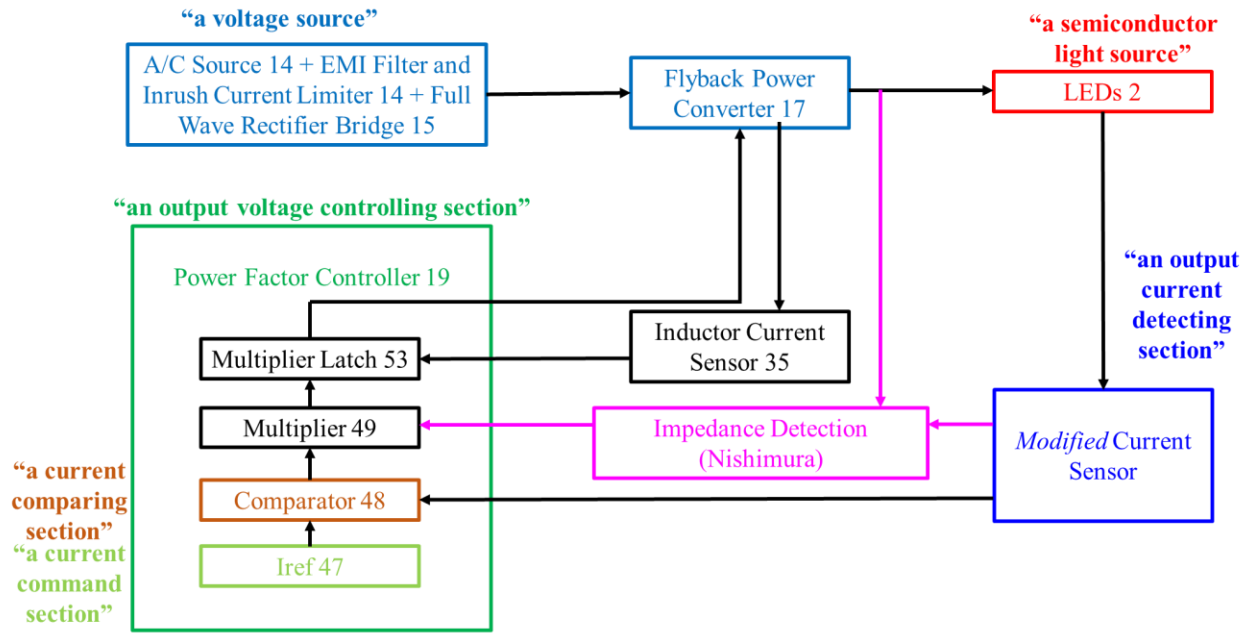
92. Using Ghanem's disclosures, below is a simplified block diagram that highlights the salient features of Figure 1 of Ghanem related to the control of current provided to the LEDs based on a detected current draw.



93. The signal leaving Output Current Filter 20 has been modified by a thermistor circuit (LED Current Sensor 10) and thus the signal includes information about the dynamic impedance of the LEDs.

94. Below is a simplified block diagram showing how a person of ordinary skill in the art would have applied Nishimura's direct impedance detection teachings to Ghanem to realize the advantages I discussed above. To perform this modification, the LED Current Sensor 10 and

Output Current Filter 20 would be removed and replaced by a single *Modified* Current Sensor that would detect the current through the LEDs, as disclosed by Nishimura. That detected current value would be supplied to comparator 48 (e.g., to be compared to Iref) as well as to the Impedance Detection section (e.g., to be used to calculate the dynamic impedance of the LEDs). The results of both the comparator 48 and impedance detection section would be supplied to multiplier 49, as I discuss further below. This Modified Current Sensor, similar to those mentioned in Section X.D.a and Nishimura, could easily be implemented by a person of ordinary skill in the art.



95. A person of ordinary skill in the art would have been familiar with block-level abstracted diagrams like the ones I presented above. There are many different ways to implement the circuit-level diagram shown above, and deriving these circuit-level diagrams based on the disclosures of Ghanem and Nishimura would have been well within the skill of a person of ordinary skill in the art.

96. Indeed, the '830 Patent does not specify or otherwise include a more granular arrangement. The '830 Patent describes each of the recited "section[s]" in the abstract and not in

terms of their underlying circuitry. For example, the '830 Patent describes these recited "section[s]" as shown below in connection with Figure 5:

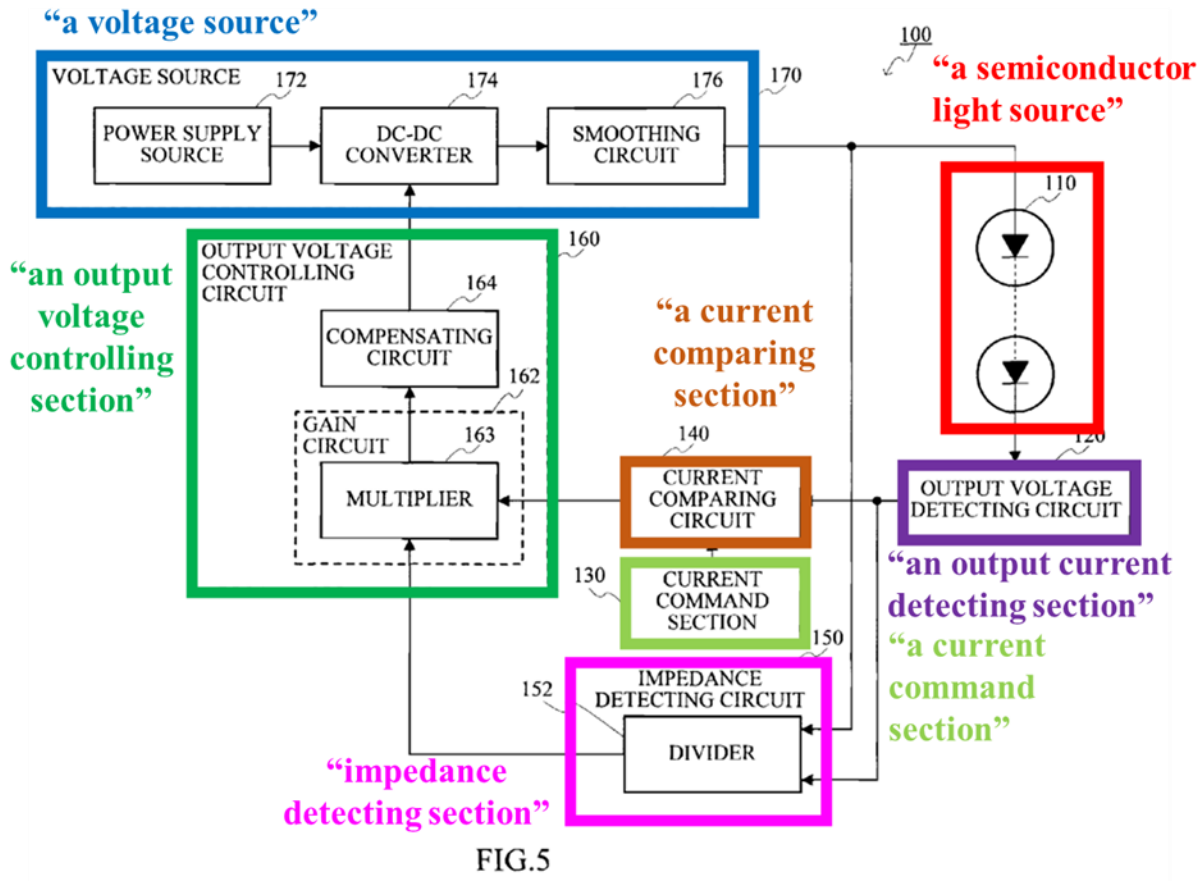


FIG.5

Ghanem at Figure 5 (annotated).[2]

97. In implementing Nishimura's impedance detection teachings in Ghanem's driver circuit, a person of ordinary skill in the art would have understood that the impedance detection section would receive a sensed voltage applied to the LEDs (e.g., the output of the flyback converter) and sensed current flowing through the LEDs (e.g., the output from the modified current sensor circuit 10) to calculate the actual impedance of the LEDs by dividing the sensed voltage by

[2] Figure 5 mislabels component 120 as an "output voltage detecting circuit," but a POSITA would have understood it is an "output current detecting circuit 120," as that is the term used throughout the specification. *E.g.*, '830, 6:32-37, 7:9-22.

the sensed current. Ghanem at 4:13-35, 6:30-61, Figure 1; Nishimura at 4:54-58, Claims 18, 24, Figure 5. As explained Section XI.D.c, a person of ordinary skill in the art would have been familiar with a divider circuit and with implementing such a circuit that performs analog division, generating a value corresponding to the impedance of the LEDs.

98. The calculated impedance value would then be fed into a multiplier (e.g., multiplier 49) that "adjust[s] its gain according to its inputs"—e.g., the result from the impedance detection section and the output from comparator 48—and supplies a signal to the multiplier latch (e.g., multiplier latch 53). Ghanem at 4:13-35, 6:30-61, Figure 1; Nishimura at 4:54-58, Claims 18, 24, Figure 5. As explained in Section XI.D.c, a person of ordinary skill in the art would have been familiar with a multiplier circuit and with implementing such a circuit that performs analog multiplication, generating a value corresponding to the impedance of the LEDs multiplied by the LED current.

99. In response, the multiplier latch would "produce [a] high or low logic level drive output" to turn a transistor in flyback power converter 17 on and off, thereby regulating the power converter to control the voltage applied to the LEDs according to changes in the detected impedance, thus controlling for a change in LED impedance. Ghanem at 6:56-7:23, Figure 1.

100. A person of ordinary skill in the art would have had a reasonable expectation of success in applying Nishimura's impedance detection teaching in implementing Ghanem's driver circuit. For example, it was known in the art to use dynamic impedance measurements to "set an operating current" of LEDs. Nishimura at 4:54-58, Claims 18, 24. A person of ordinary skill in the art would have also had a reasonable expectation of success in applying Nishimura's impedance detection teachings in implementing Ghanem, as both references teach feedback control to maintain voltage supplied to and current drawn from LEDs. Ghanem at Abstract, 4:26-

35; Nishimura at Abstract, 4:54-58. Further, both Ghanem and Nishimura disclose using control circuitry to regulate the brightness of the LEDs, specifically for LED temperature variation. Ghanem, Abstract, 2:20-24, 6:40-42; Nishimura, 1:7-11, 2:7-15, 2:22-38. Implementing Nishimura's impedance detection teaching in Ghanem's feedback controller would have required minimal modifications of Ghanem's driver circuit, as discussed above. This would have been a straightforward application of Nishimura's impedance detection teachings in a manner that advantageously improves Ghanem's driver circuit. Thus, a person of ordinary skill in the art would have found it straightforward and advantageous to apply Nishimura's impedance detection teachings to Ghanem's driver circuit, and would have known such a combination (yielding the claimed limitations) would predictably work and provide the expected functionality.

f. <u>Claim 1</u>

i. 1(pre): "1. A semiconductor light source driving apparatus comprising:"

101. This limitation is disclosed by Ghanem.

102. To the extent the preamble is limiting, Ghanem discloses a semiconductor light source driving apparatus (e.g., "electronic circuit of a light-emitting-diode lamp"). Ghanem at 2:33-39, 3:36-39, 5:23-25.

103. For example, Ghanem discloses an "electronic circuit of a light-emitting-diode lamp [i]ncorporating the current sensor circuit and a power supply system." Ghanem at 3:36-39. Ghanem further discloses that the "LEDs are driven by a constant current" using a "controllable dc voltage and current source for supplying the non-linear light emitting load with dc voltage and current" and "a voltage and current feedback circuit … to thereby adjust the dc voltage and current amplitudes that keep the light intensity produced by the light source substantially constant." *See* Ghanem at 2:33-39, 5:23-25.

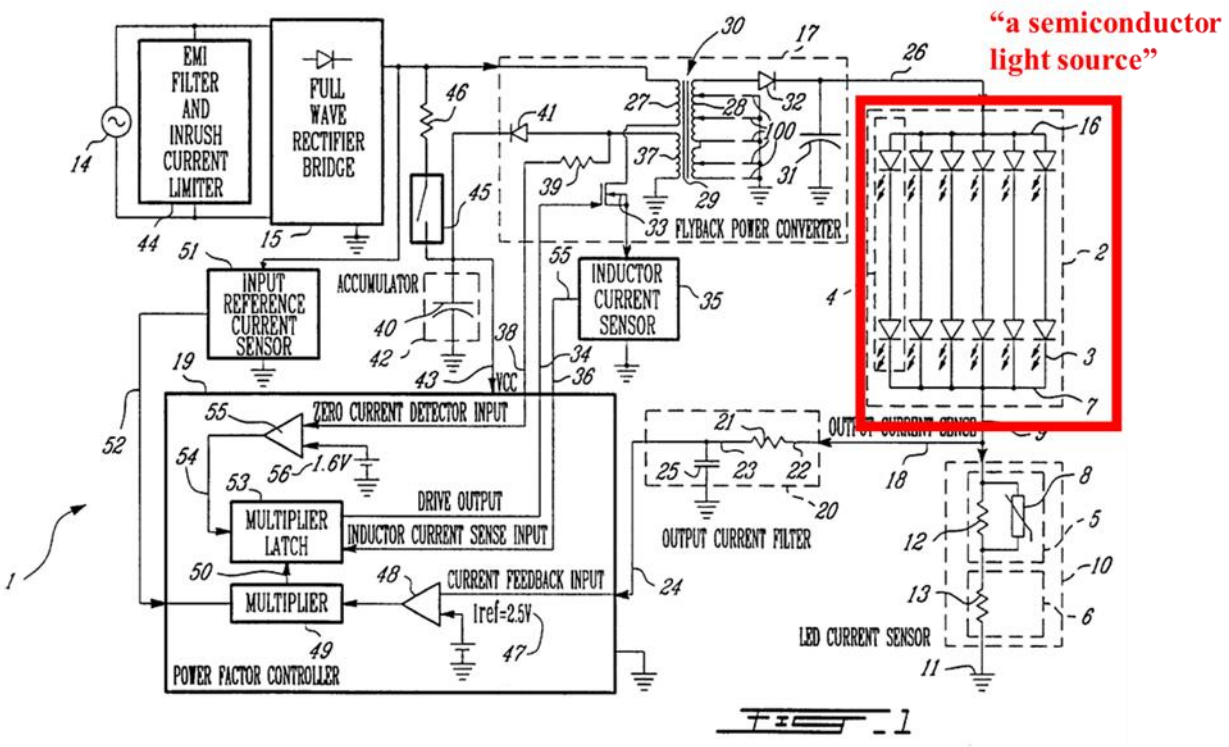
104. A person of ordinary skill in the art would have understood that an LED is a semiconductor light source. *See* '830 Patent at 1:24-25 (Patent Owner admitting "[s]emiconductor light sources include … light-emitting diodes" in the prior art). Further, a person of ordinary skill in the art would have understood that a "diode," such as the disclosed light-emitting diode in Ghanem, is a semiconductor.

ii. 1(a): "a semiconductor light source that is driven by a current;"

105. This limitation is disclosed by Ghanem.

106. Ghanem discloses a semiconductor light source that is driven by a current (*e.g.*, "LEDs … driven by a constant current"). Ghanem at 2:33-39, 3:61-67, 5:23-25, Figure 1.

107. See my discussion of element 1(pre) above (Section XI.A.f.i).



Ghanem at Figure 1 (annotated).

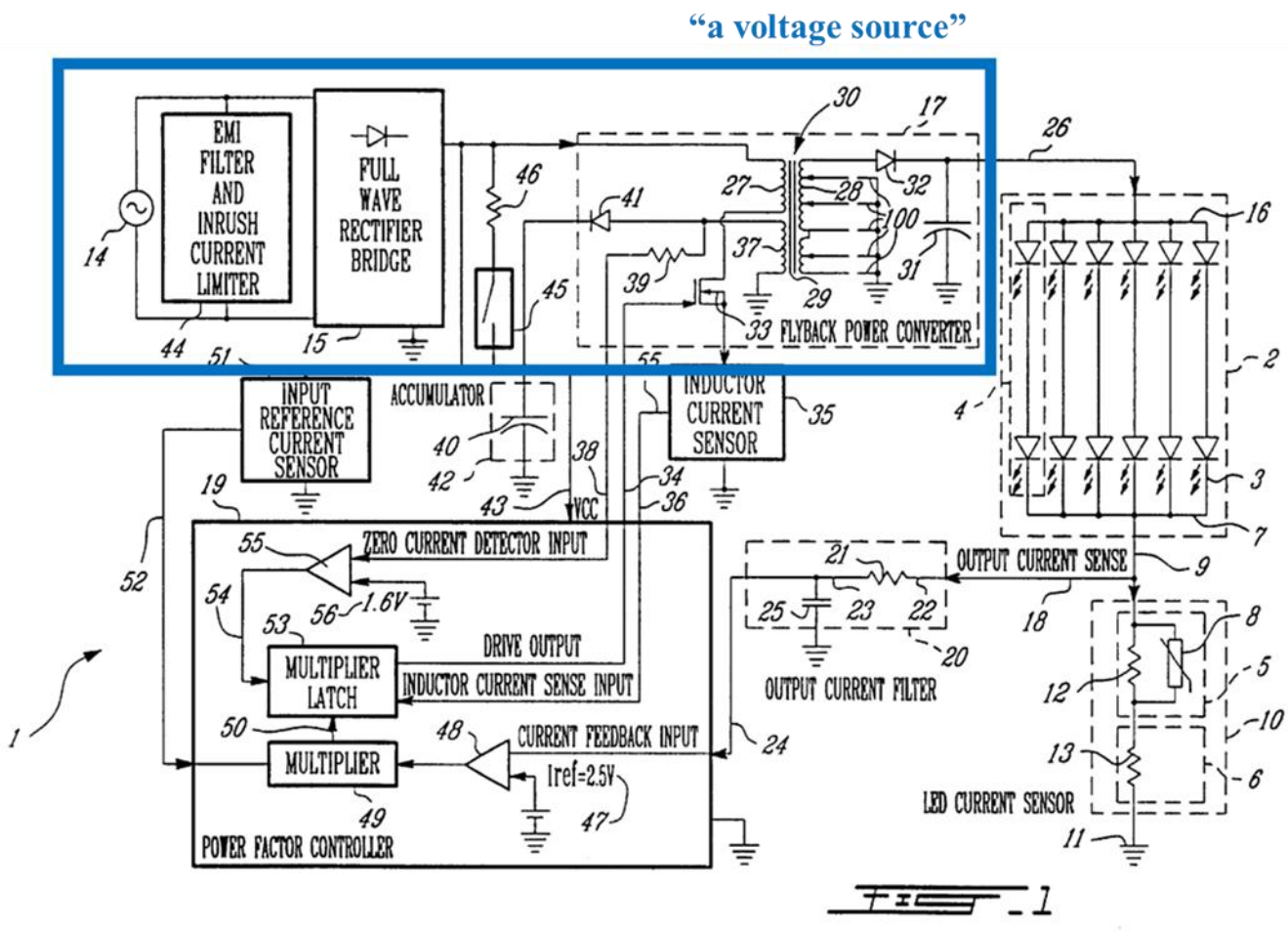
108. For example, Ghanem further discloses "a set 2 of … serially interconnected light-emitting diodes 3." Ghanem at 3:61-67. A "controllable dc voltage and current source … suppl[ies] the non-linear light-emitting load with dc voltage and current" such that the "LEDs are driven by a constant current." Ghanem at 2:33-39, 5:23-25.

iii. 1(b): "a voltage source that drives the semiconductor light source;"

109. This limitation is disclosed by Ghanem.

110. Ghanem discloses a voltage source that drives the semiconductor light source (*e.g.*, "dc voltage … source" "supplying" LEDs with "dc voltage"). Ghanem at 2:33-39, 3:11-26, 4:5-12, 4:30-35, Figure 1.

111. See my discussion of element 1(a) above (Section XI.A.f.ii).



Ghanem at Figure 1 (annotated).

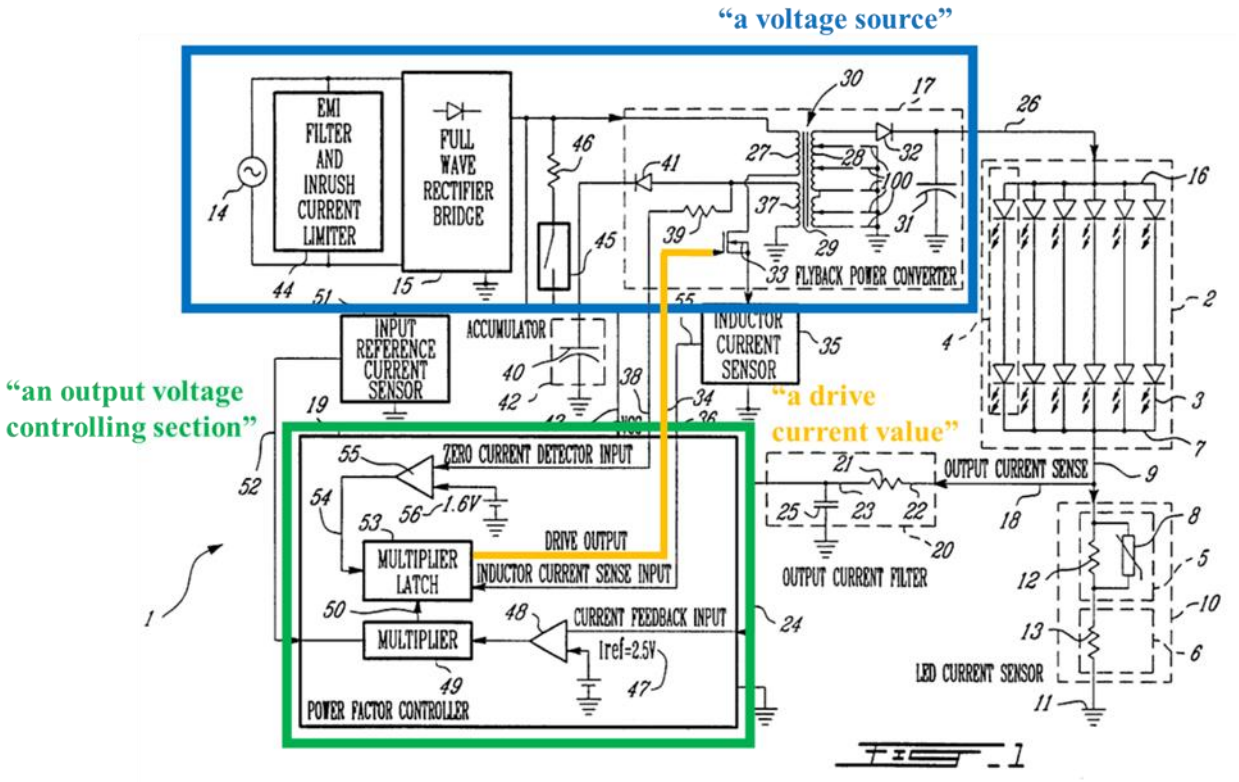
112. For example, Ghanem discloses "a controllable dc voltage and current source for supplying the non-linear light-emitting load [*i.e.*, LEDs] with dc voltage and current." Ghanem at 2:33-39. An "ac source 14" is "rectified by a full-wave rectifier bridge 15," which then supplies the rectified voltage to the LEDs "through a power converter 17." Ghanem at 4:5-12. "[T]he LED supply dc voltage" is "at the output 26 of the power converter 17." Ghanem at 4:30-35.

iv. 1(c): "an output voltage controlling section that controls a drive current value for driving the semiconductor light source by controlling an output voltage of the voltage source;"

113. This limitation is disclosed by Ghanem.

114. Ghanem discloses an output voltage controlling section (*e.g.*, "controller 19") that controls a drive current value (*e.g.*, "drive output" to "transistor 33") for driving the semiconductor light source (*see* 1(a)) by controlling an output voltage of the voltage source (*e.g.*, controls "voltage … transmitted" to LEDs). Ghanem at 4:26-35, 6:30-34, 6:56-7:23, Figure 1.

115. See my discussion of elements 1(a)-1(b) above (Sections XI.A.f.ii-iii).



Ghanem at Figure 1 (annotated).

116. For example, Ghanem discloses "controller 19 perform[s] variable current feedback control on the set 2 of non-linear light-emitting diodes 3." Ghanem at 4:26-35, 6:30-34. The controller uses "a current-representative voltage feedback signal which varies linearly with the LED supply dc voltage at the output 26 of the power converter 17." Ghanem at 4:26-35, 6:30-34. Controller 19 sends a "drive output" signal "for controlling MOSFET transistor 33" (within the "voltage source" at the end of the "drive output" line from controller 19) to "effectively control[]

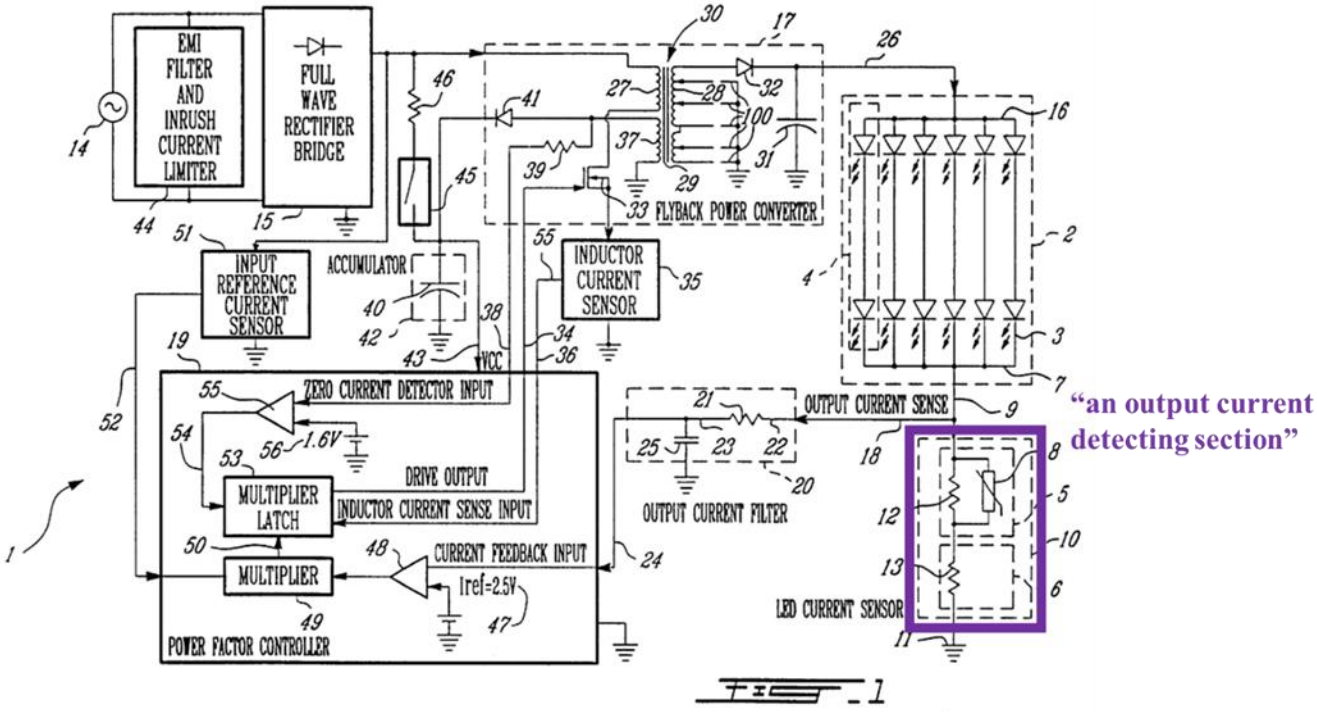
output 26 of flyback power converter 17." Ghanem at 6:58-61. Output 34 of "controller 19" is supplied to "transistor 33," which controls the "[s]upply of coil 27." Ghanem at 6:62-7:23. Doing so "induce[s] in the coil 28 rectified voltage and current transmitted" that is supplied to the LEDs. Ghanem at 6:62-7:23.

v. 1(d): "an output current detecting section that detects an output current of the semiconductor light source;"

117. This limitation is disclosed by Ghanem.

118. Ghanem discloses an output current detecting section (*e.g.*, "current sensor circuit 10") that detects an output current of the semiconductor light source (*e.g.*, "detects" "the total current flowing through" the LEDs)**.** Ghanem at Abstract, 4:13-22, 4:26-35, 5:18-20, Figure 1.

119. See my discussion of elements 1(a)-1(b) above (Sections XI.A.f.ii-iii).



Ghanem at Figure 1 (annotated).

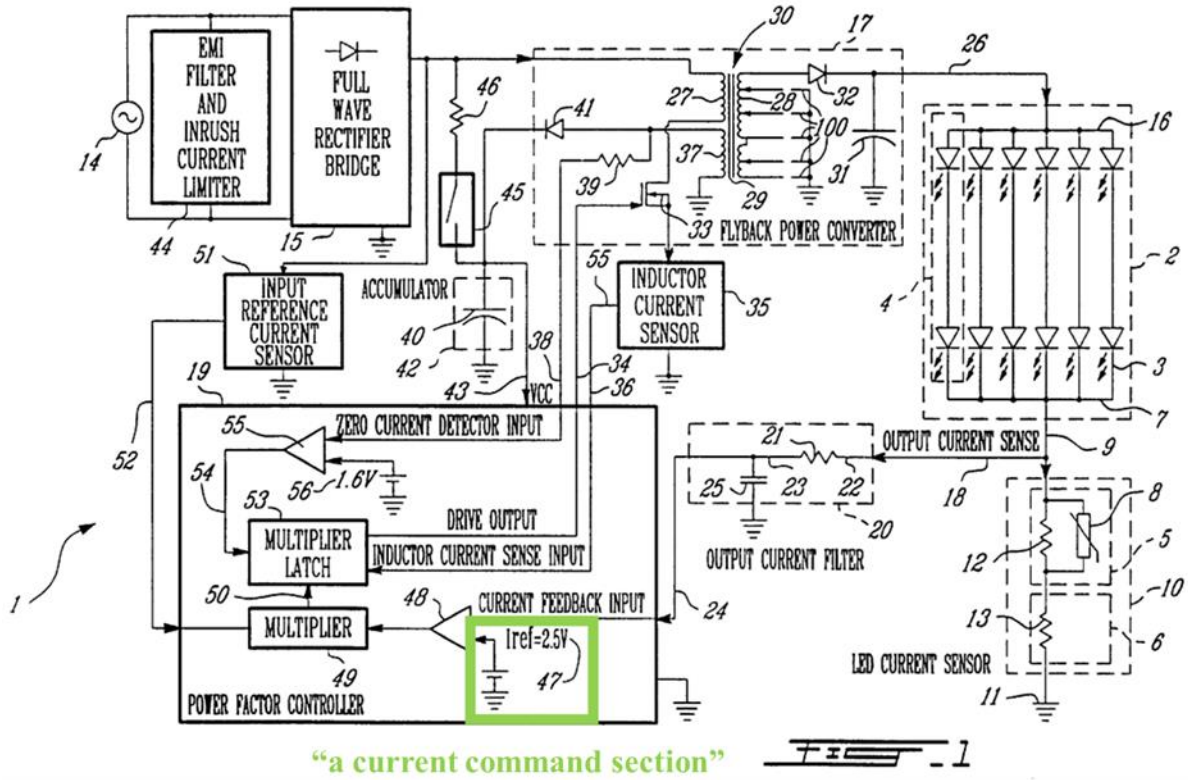
120. For example, Ghanem discloses "current sensor circuit 10" that "detects" and "convert[s] the total current flowing through the set 2 of light-emitting diodes 3 to a corresponding current-representative voltage signal present on an output 18" supplied to controller 19. Ghanem at Abstract, 4:13-22, 4:26-35. Current sensor circuit 10 uses resistors and a thermistor to "transform the non-linear relation (LED current/voltage relation with temperature) between the LED supply dc voltage at the output 26 of the power converter 17 and the dc current supplied to the set 2 of light-emitting diodes 3 with temperature into a linear relation." Ghanem at 4:30-35, 4:62-5:8. This is consistent with the '830 Patent, which discloses "[t]he output current detecting circuit may employ a method of detecting the voltage generated across a resister." '830 Patent at 7:9-13.

vi. 1(e): "a current command section that specifies a reference value of a drive current which is applied to the semiconductor light source;"

121. This limitation is disclosed by Ghanem.

122. Ghanem discloses a current command section that specifies a reference value of a drive current (*e.g.*, voltage source that specifies "reference current I_{ref}") which is applied to the semiconductor light source (*e.g.*, "I_{ref} … provid[es] a fixed LED current reference"). Ghanem at 5:33-52, 6:34-36, Figure 1.

123. See my discussion of elements 1(a) and 1(c)-1(d) above (Sections XI.A.f.ii and iv-v).



Ghanem at Figure 1 (annotated).

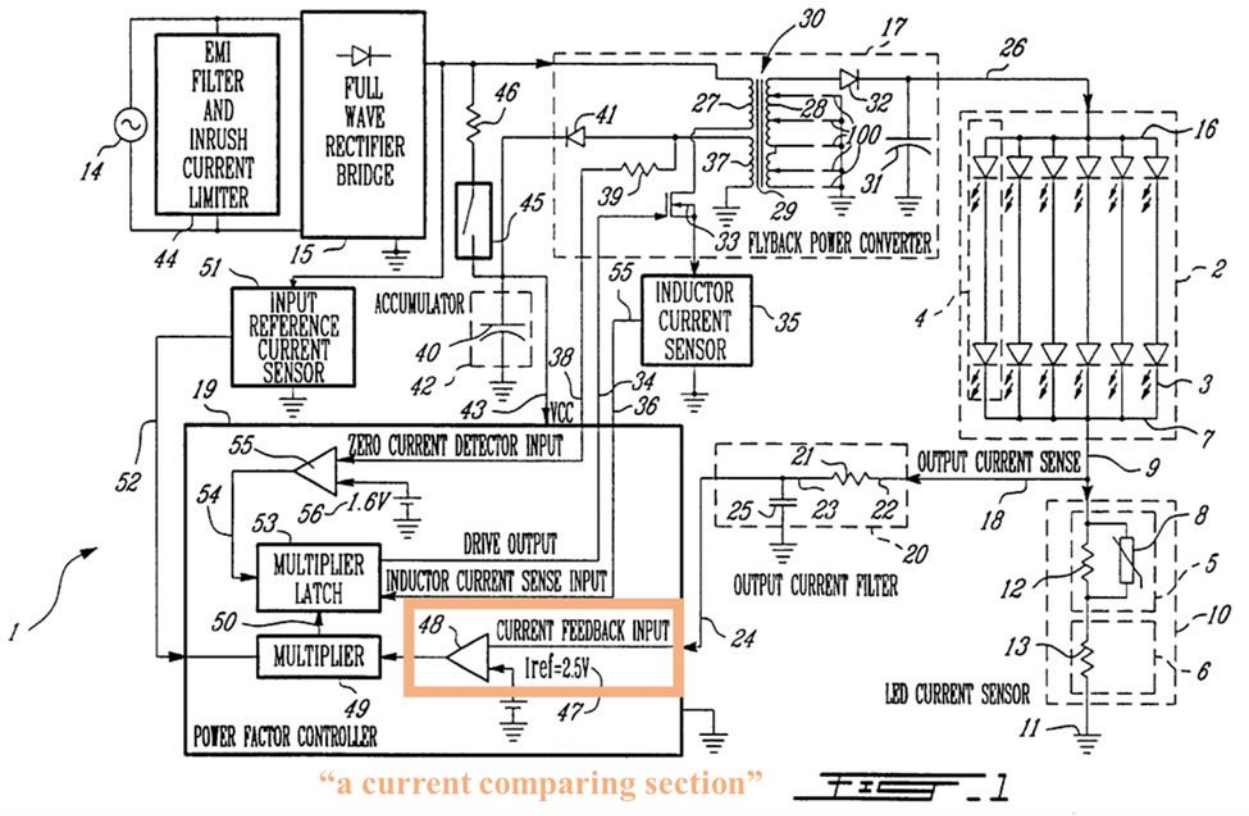
124. For example, Ghanem further discloses a "fixed reference current Iref (47)" that "is a voltage providing a fixed LED current reference." Ghanem at 5:33-52, 6:34-36. Figure 1 discloses a voltage source is used to set the Iref value, such as 2.5V.

vii. 1(f): "a current comparing section that compares the output current detected by the output current detecting section and the reference value specified by the current command section"

125. This limitation is disclosed by Ghanem.

126. Ghanem discloses a current comparing section (*e.g.*, "comparator 48") that compares the output current detected by the output current detecting section and the reference value specified by the current command section (*e.g.*, compares the "LEDs current measure I_{mes}" and the "reference current I_{ref}"). Ghanem at 5:18-22, 5:48-52, 6:16-20, 6:30-38, Figure 1.

127. See my discussion of elements 1(a) and 1(c)-1(e) above (Sections XI.A.f.ii and iv-vi).



Ghanem at Figure 1 (annotated).

128. For example, Ghanem discloses "comparator 48" compares "current-representative voltage feedback signal on input 24" (I_{mes}) to "I_{ref} (47)." Ghanem at 6:30-38. The "LEDs current measure I_{mes} (24)" is the "output 18 of the current sensor circuit 10" after passing through "output current filter 20," which includes a low pass filter comprising a resistor and capacitor that a person of ordinary skill in the art would have understood filters high-frequency signals. Ghanem at 5:48-52, 6:16-20, Figure 1. Therefore, the current I_{mes} has an "amplitude that is proportional to the magnitude of the current flowing through the current sensor circuit 10." Ghanem at 5:18-22. Based on the result of the comparison by comparator 48, "the LED current is increased by the power

supply until the difference $E=I_{ref}-I_{mes}$ equals zero." Ghanem at 5:48-52. This is consistent with the '830 Patent, which "compares the output current value detected by output current detecting circuit 120 and the reference value … to find the difference between the output current value and the reference value." '830 Patent at 7:23-31.

viii. 1(g): "an impedance detecting section that detects an impedance of the semiconductor light source,"

129. This limitation is disclosed by Nishimura, and alternatively rendered obvious by Ghanem.

130. Nishimura discloses an impedance detecting section (*e.g.*, "control circuitry 506" that "acquire[s] readings from the [LEDs'] current and voltage sensors 502, 504") that detects an impedance of the semiconductor light source (*e.g.*, "estimate[s] a dynamic impedance of the LED[s]"). Nishimura at 4:48-58, Claims 18, 24, Figure 5.

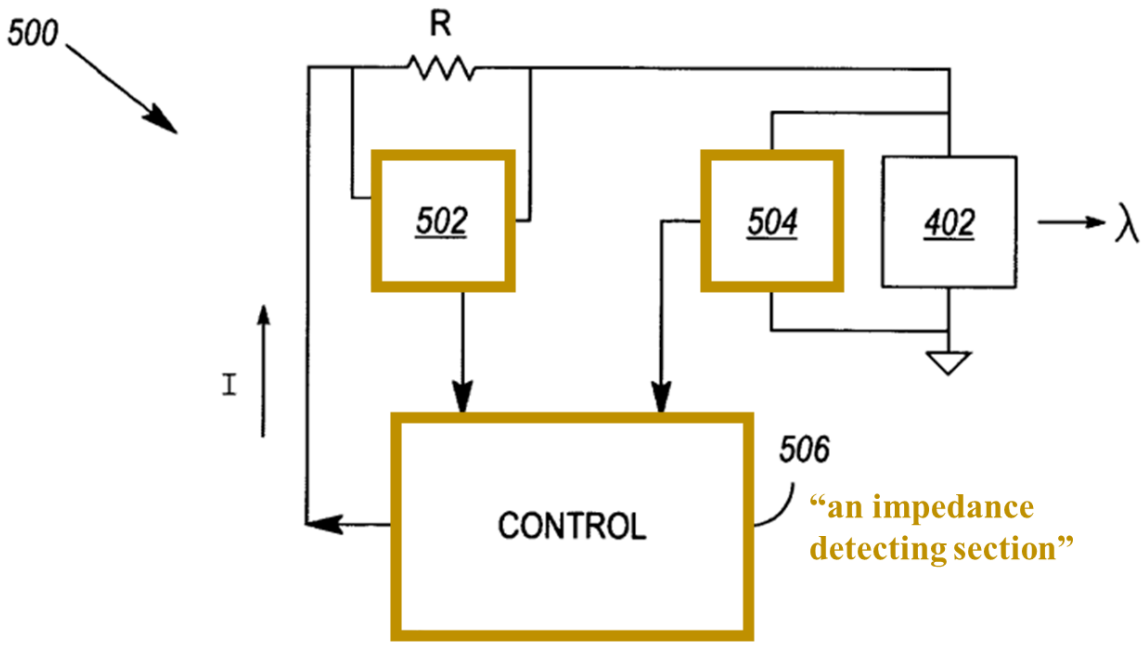


FIG. 5

Nishimura at Figure 5 (annotated).

131. For example, Nishimura discloses an LED driver circuit that includes "a current sensor 502, a voltage sensor 504 and control circuitry 506" associated with "at least some of the LEDs." Nishimura at 4:48-51. The current sensor "measures the operating current supplied to the LED 402," and the "voltage sensor 504 measures a voltage of the LED 402." Nishimura at 4:51-54. Control circuitry 506 "coupled to … sensors 502, 504" to "set an operating current (I) of the LED 402 in response to acquired readings from the LED's current and voltage sensors 502, 504," such as by "estimat[ing] a dynamic impedance of the LED." Nishimura at 4:54-58, Claims 18, 24. The current sensor 502, voltage sensor 504, and control circuitry 506 jointly disclose an impedance detecting section. This is consistent with the '830 Patent, which describes "find[ing] … a value corresponding to the impedance of semiconductor light source 110 … by div[id]ing the output voltage of voltage source 170 supplied to semiconductor light source 110 by the output current of semiconductor light source 110 detected by output current detecting circuit 120." '830 Patent at 7:32-47.

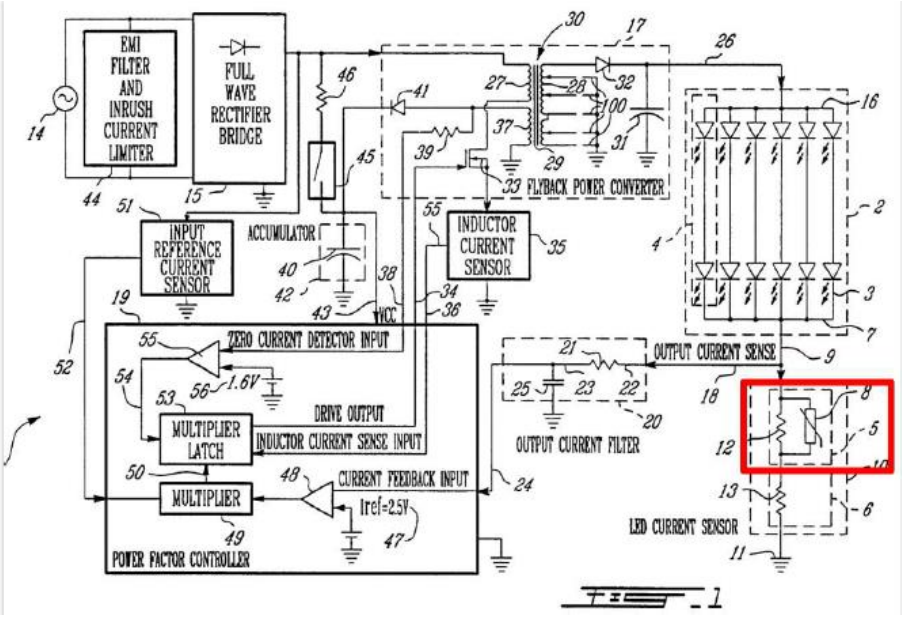
132. As discussed in Section XI.A.e, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Ghanem's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance.

133. Alternatively, Ghanem renders obvious an impedance detecting section that detects an impedance of the semiconductor light source.

134. Recognizing the non-linear and temperature-dependent impedance of LEDs (Ghanem at 4:40-44, Figure 2), Ghanem discloses a "current sensor circuit 10" that "transform[s] the non-linear relation (LED current/voltage relation with temperature) between the LED supply dc voltage at the output 26 of the power converter 17 and the dc current supplied to the set 2 of

light-emitting diodes 3 … into a linear relation" in order "[t]o enable the controller 19 to perform variable current feedback control on the set 2 of non-linear light-emitting diodes 3." Ghanem at 4:26-35. As such, the LED current sensor 10 both "detect[s] a current supplied to a non-linear load" (e.g., LEDs) and "produc[es] a current reading dependent on a condition of operation of the non-linear load" that corrects for the dynamic impedance of the LEDs in order to perform feedback voltage control to "keep the light intensity produced by the light source substantially constant." Ghanem at 2:7-10, 2:33-54.

135. Ghanem further discloses that "current sensor circuit 10" includes a "temperature dependent variable equivalent impedance Zeq" that is based on "thermistor RTH (8)." Ghanem at 4:62-66.



Ghanem at Figure 1.

136. However, a person of ordinary skill in the art would have recognized that the thermistor solution of Ghanem would not be the best available option to "keep the light intensity produced" by the LEDs "substantially constant" because the thermistor is a separate device from the LEDs and therefore is only an indirect analog for the dynamic impedance of the LEDs.

Ghanem at 2:33-54, 4:26-35. A person of ordinary skill in the art would have recognized that the changes in impedance to the LEDs would not be completely compensated for through changes in the impedance of the thermistor because the dynamic impedance of the thermistor is not dependent on the dynamic impedance of the LEDs. For example: (1) the temperature at the thermistor may change differently than at the LEDs; (2) the LEDs may age differently than the thermistor; (3) the thermistor may respond differently than the LEDs at different currents, voltages, and/or temperatures; and (4) the dynamic impedance of the thermistor may not perfectly match what is necessary to "transform the non-linear … relation into a linear relation" for a particular set of LEDs.

137. Ghanem itself recognized that it disclosed "a simple-low cost circuit" and also taught using other components (e.g., power factor controller). Ghanem at 2:26-32, 8:37- 48. A person of ordinary skill in the art would have recognized that there were other design choices available that would perform better than the thermistor of Ghanem to "keep the light intensity produced" by the LEDs "substantially constant." *Id*. A solution that would have been obvious to a person of ordinary skill in the art would be direct measurement of the impedance of the LEDs, for example, using Ohm's Law: (V=I*R; or R=V/I), as I discussed above in Section X.B. Ghanem already discloses that a current sensor and voltage sensor were well-known and to implement them at "the LED supply dc voltage at the output 26 of the power converter 17." *Id.*, 6:30-34. Similarly, closed-loop feedback control was a well-known technique for controlling current to LEDs in dynamic circuits and, generally comprises measuring a changing variable and then compensating for that change. In this case, Ghanem recognized the need to compensate for the dynamic impedance of the LEDs and standard feedback control instructs a person of ordinary skill in the art to measure the impedance (the dynamic component) and then correct for it.

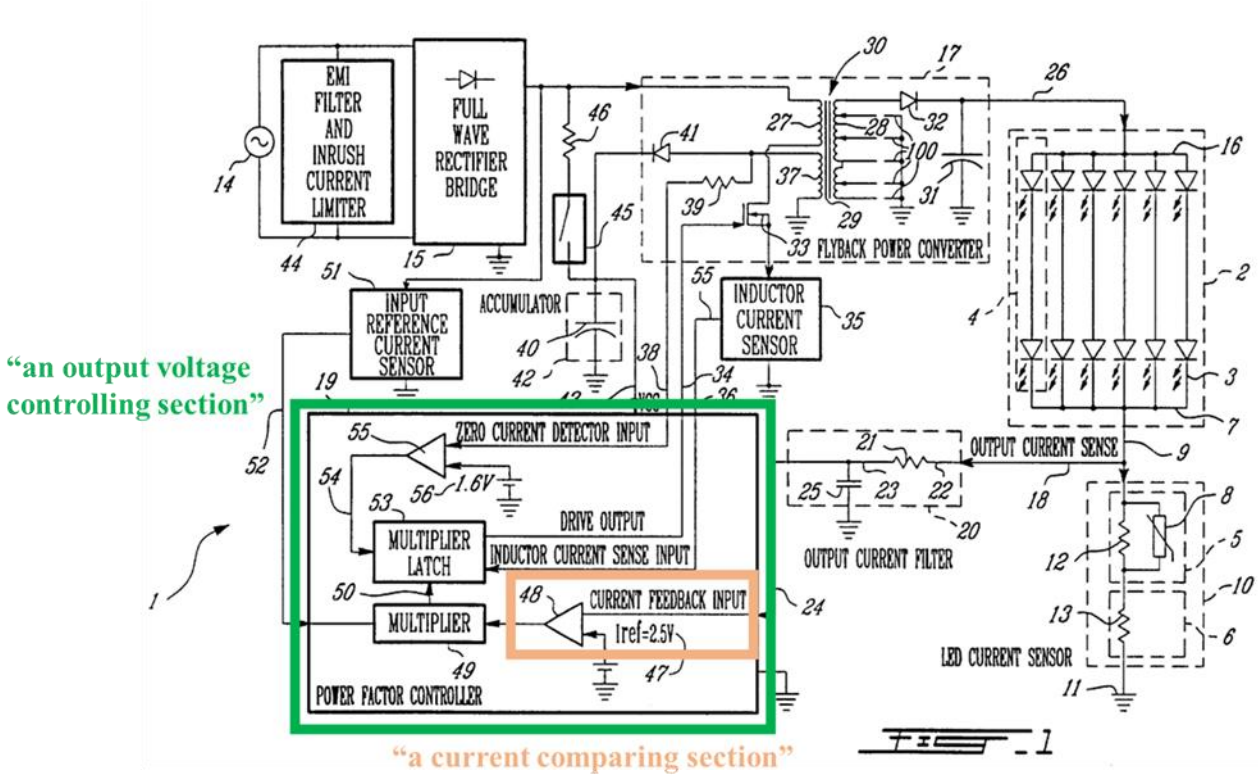
138. A person of ordinary skill in the art would have understood that and been motivated to implement a direct measurement of impedance with a reasonable expectation of success through application of the well-known Ohm's law (as I discussed above in Section X.B), by dividing the LED supply voltage (either known based on supply voltage or measured before the voltage drop across the LEDs using well-known voltage sensors) by the output current of the LEDs ("output current sense" / "current feedback input" signal of Ghanem). Ghanem at Figure 1. A person of ordinary skill in the art would have been motivated (and readily able) to apply this basic calculation, because a direct impedance measurement of the LEDs would be dependent on the impedance of the LEDs and accordingly more accurate than the thermistor, which is only an indirect analog for the impedance of the LEDs. As opposed to using a thermistor to compensate for the dynamic impedance of the LEDs, a direct impedance measurement of the LEDs would allow for the correction of additional factors that impact LED impedance, such as aging, making it a more robust solution. As such, a person of ordinary skill in the art would understand that a direct impedance measurement of the LEDs would better provide "substantially constant intensity light source" (as desired in Ghanem) than the thermistor solution disclosed by Ghanem. Ghanem at Abstract. And at minimum, these teachings in Ghanem and what was known in the art provide yet further motivation to apply Nishimura's teachings.

ix. 1(h): "wherein the output voltage controlling section controls the output voltage of the voltage source based on an output of the current comparing section and an output of the impedance detecting section."

139. This limitation is rendered obvious by Ghanem in view of Nishimura, and alternatively by Ghanem alone.

140. Ghanem discloses the output voltage controlling section controls the output voltage of the voltage source (*see* 1(c)) based on an output of the current comparing section (*e.g.*, "output of comparator 48"). Ghanem at 6:30-61, Figure 1.

141. See my discussion of elements 1(b)-1(c) and 1(f) above (Sections XI.A.f.iii-iv and vii).



Ghanem at Figure 1 (annotated).

142. For example, Ghanem further discloses the "output of comparator 48 is a high/low difference-representative signal fed to multiplier 49," which "produces a corresponding current reference waveform signal 50" that is fed into "multiplier latch 53." Ghanem at 6:30-61, Figure 1. The multiplier latch 53 "produce[s] the high or low logic level drive output for controlling MOSFET transistor 33 on or off thereby effectively controlling output 26 of flyback power converter 17." Ghanem at 6:30-61, Figure 1.

143. Nishimura discloses controlling the output voltage of the voltage source (*e.g.*, "set an operating current (I) of the LED[s]") based on the impedance detecting section (*see* 1(g)). Nishimura at 4:54-58, Claim 18, 24.

144. A person of ordinary skill in the art would have understood or at least found it obvious that the voltage supplied to the LEDs is controlled by "set[ting] operating current … of the LED." Nishimura at 4:54-58. For example, the voltage supplied would vary based on the operating current set by control circuit 506, as a voltage is produced when the current flows through the resistor and LED 402. Nishimura at Figure 5, 4:51-54 ("LED's current sensor 502 measures the operating current supplied to the LED 402 (e.g., by sensing the ***voltage across a series resistor R)***."). Therefore, Nishimura discloses control circuitry sets this operating current, and thus the voltage supplied to the LEDs, by "estimat[ing] a dynamic impedance of the LED." Nishimura at Claim 18, 24.

145. As discussed in Section XI.A.e, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Ghanem's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance. As also discussed in Section XI.A.e, in implementing Nishimura's impedance detection teachings in Ghanem's circuit, the controller 19 would have controlled the output voltage on output 26 based on the detected impedance result taught by Nishimura.

146. Alternatively, Ghanem renders obvious controlling the output voltage of the voltage source based on the impedance detecting section.

147. As discussed in 1(g) (§IX.A.4.h), it would have been obvious to make direct impedance measurements of the LEDs to compensate for the dynamic impedance of the LEDs using standard closed-loop control, rather than rely on the "simple low-cost circuit" using the

thermistor of Ghanem. For the reasons I discussed above in 1(g), it would have further been obvious to provide the direct impedance measurement to an "output voltage controlling section" to "control the output voltage of the voltage source. A person of ordinary skill in the art would have understood to modify the "power factor controller 19" of Ghanem to further receive the detected impedance and to compensate for the dynamic impedance of the LEDs in determining a voltage to apply to maintain a constant current to the LEDs.

148. A person of ordinary skill in the art would have recognized that there are many ways to use the detected impedance in closed-loop voltage control and would have been motivated to apply these well-known teachings to advantageously account for the changing impedance of the LED. For example, a person of ordinary skill in the art would have known to simply multiply the impedance value by the current using analog circuitry ($V = Z \times I$) and compare the result to a reference to determine the amount of voltage change required to keep a constant current flowing in the LEDs. As another example, a person of ordinary skill in the art would have known and found it obvious to store the impedance and current values in a register or memory and compare them to themselves to identify changes over time ($\Delta Z/t$, $\Delta I/t$) and to use these changes to modify the gain to increment the output voltage either up or down to maintain constant LED current. These modifications would allow for more accurate and reliable control over the LED current than the thermistor of Ghanem.

149. A person of ordinary skill in the art would have further understood that voltage control would only need to be performed when the output of comparator 48 detects that the LED current was different from the reference current. Ghanem at 6:36-38 ("The output of comparator 48 is a high/low difference-representative signal fed to multiplier 49.").

150. As opposed to using a thermistor to compensate for the dynamic impedance of the LEDs, a direct impedance measurement of the LEDs would allow for the correction of additional factors that impact LED impedance, such as aging, making it a more robust solution.

151. Accordingly, it would have been obvious to a person of ordinary skill in the art to improve the circuit of Ghanem by replacing the thermistor with a direct impedance measurement (as discussed in 1(g)), and to use the impedance measurement ("output of the impedance detecting section") with the existing output of comparator 48 ("output of the current comparing section") to "control[] the output voltage of the voltage source" as recited in claim 1. And, at minimum, this knowledge of a person of ordinary skill in the art would provide yet further motivation to apply Nishimura's teachings to Ghanem.

g. Claim 2

152. Claim 2 recites "The semiconductor light source driving apparatus according to claim 1, wherein the impedance detecting section comprises a divider that divides the output voltage of the voltage source by the output current detected by the output current detecting section, and acquires a value corresponding to the impedance of the semiconductor light source from an output of the divider."

153. Ghanem in view of Nishimura renders obvious claim 1 (Section IX.A.4).

154. Ghanem discloses the output voltage of the voltage source (*see* 1(c), 1(h)), the output current detected by the output current detecting section (*see* 1(d)), and the semiconductor light source (*see* 1(a)).

155. Nishimura discloses the impedance detecting section comprises a divider (*e.g.*, "control circuitry" that performs division) that divides voltage by current (*e.g.*, divides "voltage of the LED" by "operating current supplied to the LED") and acquires a value corresponding to the

impedance (*e.g.*, acquires value of "a dynamic impedance of the LED") from an output of the divider (*e.g.*, output of "control circuitry" that performs division). Nishimura at 2:64-3:5.

156. See my discussion of element 1(g) above (Section XI.A.f.viii).

157. As discussed in 1(g), Nishimura discloses control circuitry 506 that estimates a dynamic impedance of the LED using readings from voltage and current sensors. Nishimura further discloses that the dynamic impedance of the LEDs is estimated by dividing the measured voltage of the LEDs by the measured current of the LEDs. Nishimura at 2:64-3:5 ("ΔV/ΔI=R; where ΔV is the difference in two measured voltages of the LED, where ΔI is the difference in the currents corresponding to the measured voltages, and where R is the LED's dynamic impedance."). A person of ordinary skill in the art would have understood or at least found obvious that Nishimura teaches that the control circuitry 506 includes a divider to perform the division, such that the control circuitry acquires a value corresponding to the dynamic impedance of the LED from the output of such control circuitry.

158. As discussed in Section XI.A.e, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Ghanem's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance.

h. <u>Claim 3</u>

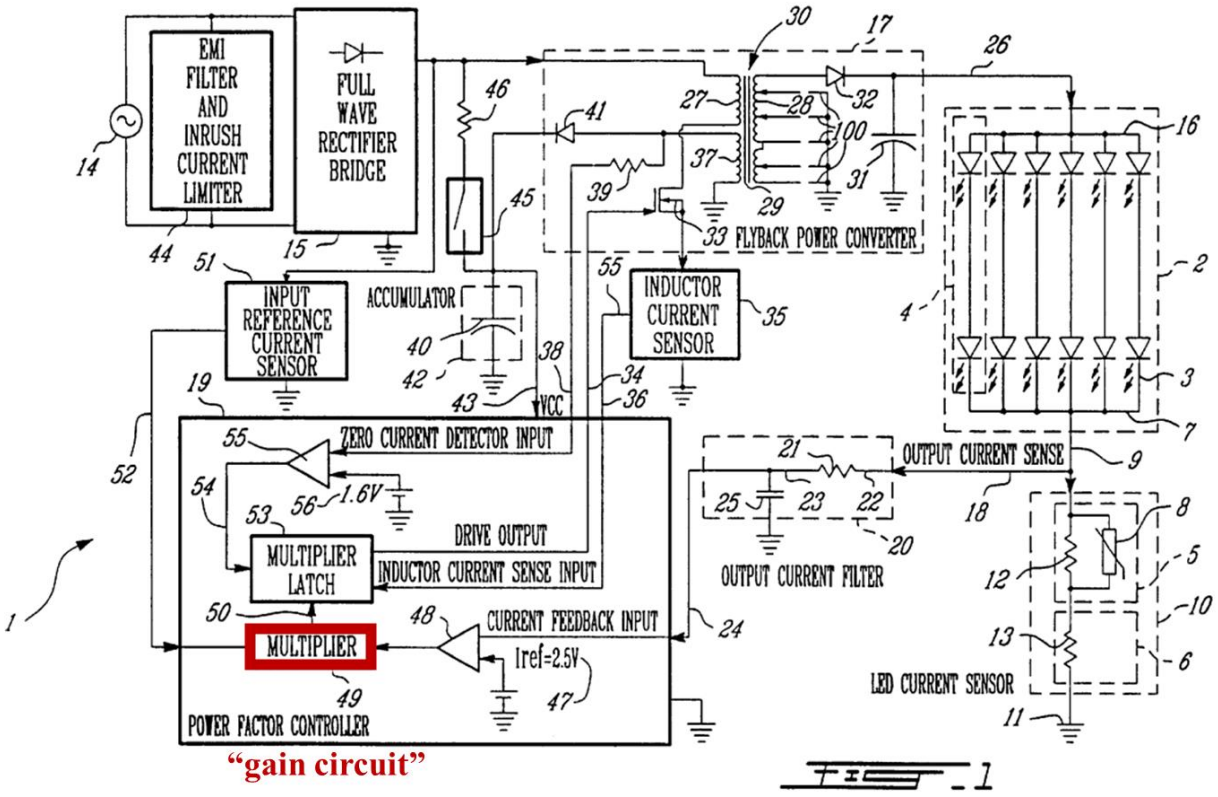
159. Claim 3 recites "The semiconductor light source driving apparatus according to claim 1, wherein: the output voltage controlling section comprises a gain circuit that sets a gain; and the gain circuit multiplies the impedance of the semiconductor light source detected by the impedance detecting section and the output of the current comparing section to prevent a gain of a control loop from changing even when the impedance of the semiconductor light source changes."

160. Ghanem in view of Nishimura renders obvious claim 1 (Section IX.A.4).

161. Ghanem discloses the output voltage controlling section (*see* 1(c), 1(h)) comprises a gain circuit (*e.g.*, "multiplier 49") that sets a gain (*e.g.*, "multiplier 49 … adjusts its gain"); and the gain circuit multiplies (*e.g.*, "multiplier 49" multiplies) and the output of the current comparing section (*e.g.*, "output of comparator 48") to prevent a gain of a control loop from changing (*e.g.*, "[m]ultiplier 49 adjusts its gain according to its inputs" to "effectively control[] output 26 of flyback power converter 17"). Ghanem at 6:40-61, Figure 1.

162. See my discussion of elements 1(c) and 1(h) above (Sections XI.A.f.iv and ix).

163. For example, as discussed in 1(h), Ghanem discloses that feedback controller 19 includes multiplier 49 that is fed the "output of comparator 48." Ghanem at 6:36-38. The multiplier "adjusts its gain according to its inputs" and produces signal 50 that is used to regulate the voltage applied to the LEDs, as discussed in 1(c) and 1(h). Ghanem at 6:40-61, Figure 1. Therefore, a person of ordinary skill in the art therefore would have understood or at least found it obvious that the multiplier is disclosed to prevent the gain of the control loop from changing because it adjusts the characteristics of the control loop, such as the control loop's gain, to the optimal value so that a constant voltage is supplied to the LEDs. This is consistent with the '830 Patent, which discloses a gain circuit that "prevent[s] the gain of the control loop from changing" by "automatically adjust[ing] the characteristics of the current control loop, to the optimal value according to the detected impedance equivalent value." '830 Patent at 7:62-8:4.



Ghanem, Fig. 1.

164. Further, a person of ordinary skill in the art would have understood or at least found it obvious that the multiplier multiplies signals. For example, U.S. Pat. No. 2007/0091995 (Ex. 1012, "Ibragimov") discloses that "feedback signals 111 a, 111 b are ***multiplied*** in their respective ***multiplier circuits*** 202 a, 202 b," disclosing a multiplier that multiplies signals. Ibrgimov, [0062]. Further, U.S. Pat. No 8,090,198 (Ex. 1013, Yoshii) discloses that "a ***multiplier*** in the gradation corrector 6 [that] ***multipl[ies]*** the color difference signals DbBY and DbRY by appropriate parameters," disclosing a multiplier that multiplies signals. Yoshii, 29:44-48.

165. Nishimura discloses the impedance of the semiconductor light source (*e.g.*, "dynamic impedance of the LED") detected by the impedance detecting section (*e.g.*, "control circuitry 506").

166. See my discussion of element 1(g) above (Section XI.A.f.viii).

167. As discussed in Section XI.A.e, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Ghanem's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance.

168. As discussed in Section XI.A.e, in implementing Nishimura's teachings in Ghanem's driver circuit, a person of ordinary skill in the art would have understood that the multiplier would receive both the output from comparator 48 (as taught by Ghanem) and the detected impedance result (as taught by Nishimura), and would have multiplied those inputs and adjusted its gain to regulate the voltage applied to the LEDs. Such an implementation would have advantageously prevented the gain of the control loop from changing even when the impedance of the LEDs changes such that a constant voltage is applied to them regardless of such changes.

i. Claim 4

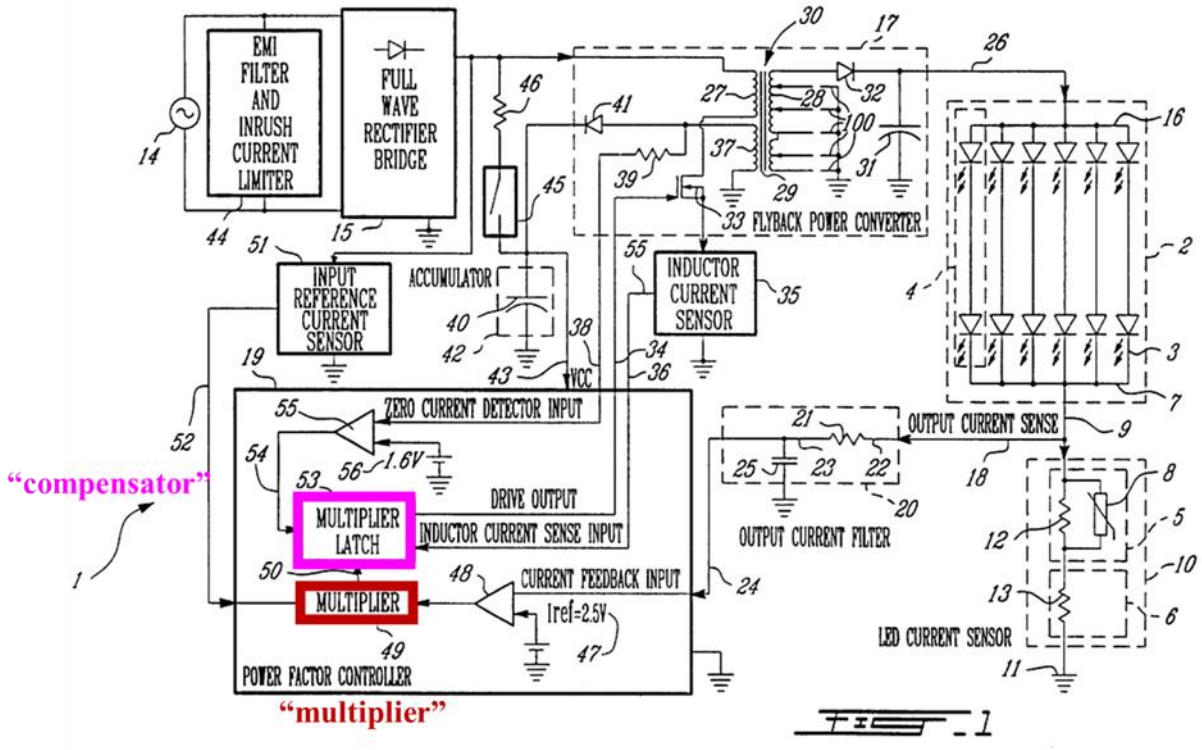
169. Claim 4 recites "The semiconductor light source driving apparatus according to claim 1, wherein the output voltage controlling section comprises: a multiplier that multiplies the impedance of the semiconductor light source detected by the impedance detecting section and the output of the current comparing section; and a compensator that performs predetermined processing with respect to an output of the multiplier to compensate for control characteristics."

170. Ghanem in view of Nishimura renders obvious claim 1 (Section IX.A.4).

171. Ghanem discloses the output voltage controlling section (*see* 1(d)) comprises: a multiplier (*e.g.* "multiplier 49") that multiplies the output of the current comparing section (*see* 1(f), 1(h)); and a compensator (*e.g.*, "multiplier latch 53") that performs predetermined processing with respect to an output of the multiplier (*e.g.*, "passes from a high logic level to a low logic level" if "voltage signal from the inductor current sensor 36 … exceeds the amplitude of the signal 50 from the multiplier 49") to compensate for control characteristics (*e.g.*, "prevent the dc current

through" the LEDs from "exceed[ing] a safe level" / "ensure[] that a single pulse appears at the drive output during a given cycle "). Ghanem at 6:54-61, 7:49-56, 7:63-8:3, Figure 1.

172. See my discussion of elements 1(d), 1(f), and 1(h) above (Sections XI.A.f.v, vii, and ix).



Ghanem at Figure 1 (annotated).

173. For example, as discussed in 1(h), Ghanem discloses that feedback controller 19 includes multiplier 49 that is fed the "output of comparator 48." Ghanem at 6:36-38. Ghanem further discloses that "multiplier latch 53" receives a voltage signal "from the inductor current sensor 35" and "signal 50 from multiplier 49." Ghanem at 6:54-61, 7:49-56, 7:63-8:3. If "the voltage signal from the inductor current sensor 36 … exceeds the amplitude of the signal 50 from the multiplier 49," the multiplier latch 53 "passes from a high logic level to a low logic level" and turns off transistor 33 to "prevent the dc current through the set 3 of light-emitting diodes 3

exceed[ing] a safe level." Ghanem at 7:63-8:3. The multiplier latch also "ensures that a single pulse appears at the drive output during a given cycle." Ghanem at 6:56-61. As discussed in claim 3 (§IX.A.h), a person of ordinary skill in the art would have understood or at least found obvious that a multiplier multiplies signals.

174. Nishimura discloses the impedance of the semiconductor light source (*e.g.*, "dynamic impedance of the LED") detected by the impedance detecting section (*e.g.*, "control circuitry").

175. See my discussion of elements 1(g) and (2) above (Sections XI.A.f.viii and XI.A.g).

176. As discussed in Section XI.A.e, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Ghanem's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance.

177. As discussed in Section XI.A.e, in implementing Nishimura's teachings in Ghanem's circuit, a person of ordinary skill in the art would have understood that the multiplier would receive both the output from comparator 48 (as taught by Ghanem) and the detected impedance result (as taught by Nishimura), and would have multiplied those inputs and provided the result to multiplier latch 53.

j. Claim 5

178. As discussed above, the limitations of claim 5 are subsumed within claim 1. See my comparison of the claims above in Section VII.D (table correlating claim 5 with claim 1).

179. Claim 5 is rendered obvious by Ghanem in view of Nishimura, or alternatively Ghanem alone, for the same reasons as described above regarding Ground 1, Claim 1 (Section XI.A.e).

B. GROUND 2: TRIPATHI IN VIEW OF NISHIMURA

a. Status of Tripathi as Prior Art

180. "Tripathi" refers to United States Patent No. 7,262,559, entitled "LEDS Driver" and naming Ajay Tripathi and others as inventors. Tripathi was filed as a PCT application on December 11, 2003, published in the United States as publication no. 2006/0071614 on April 6, 2006, and issued in the United States on August 28, 2007. Thus, Tripathi published and issued in the United States more than one year before the '830 Patent was filed in the United States (July 1, 2009). Accordingly, I understand that Tripathi qualifies as prior art to the '830 Patent.

b. Overview of Tripathi

181. Similar to the '830 Patent, Tripathi is directed to a "power supply for LEDs" that is "designed to precisely regulate the LED current to prevent luminous intensity variations," including in an "LED light source … having a variable number of LEDs wired in series and/or in parallel." Tripathi at Abstract, 1:9-10, 1:27-31. Tripathi recognizes that the brightness "of LEDs depends on the LED current." Tripathi at 1:22-27. Tripathi further recognizes that "electrical characteristics of LEDs are such that small changes in the voltage applied to the LED lamp will cause appreciable current changes." *Id.*, 1:22-27.

182. As illustrated in Figure 1 below, Tripathi discloses "a power supply for an LED light source" that includes an "**LED light source 10**" coupled to a **voltage source** that supplies "LED current and a LED voltage" to LEDs. Tripathi at 2:4-6, 2:18-24. An "**LED current sensor 25**" detects the "magnitude of the LED current flowing through **LED light source 10**" and provides the detected current to a "**feedback controller 27**," where it is "**compare[d]**" "to a reference signal" from a "**signal reference 28**." Tripathi at Abstract, 2:28-42. The **feedback controller 27** then uses the comparison result to "provide[] a feedback signal" FB to the **voltage source**. Tripathi at 1:26-31, 2:38-45. The power supply "precisely regulate[s]" the "LED current

flowing through **LED light source 10**" to "prevent luminous intensity variations." Tripathi at 1:26-31, 2:38-45.

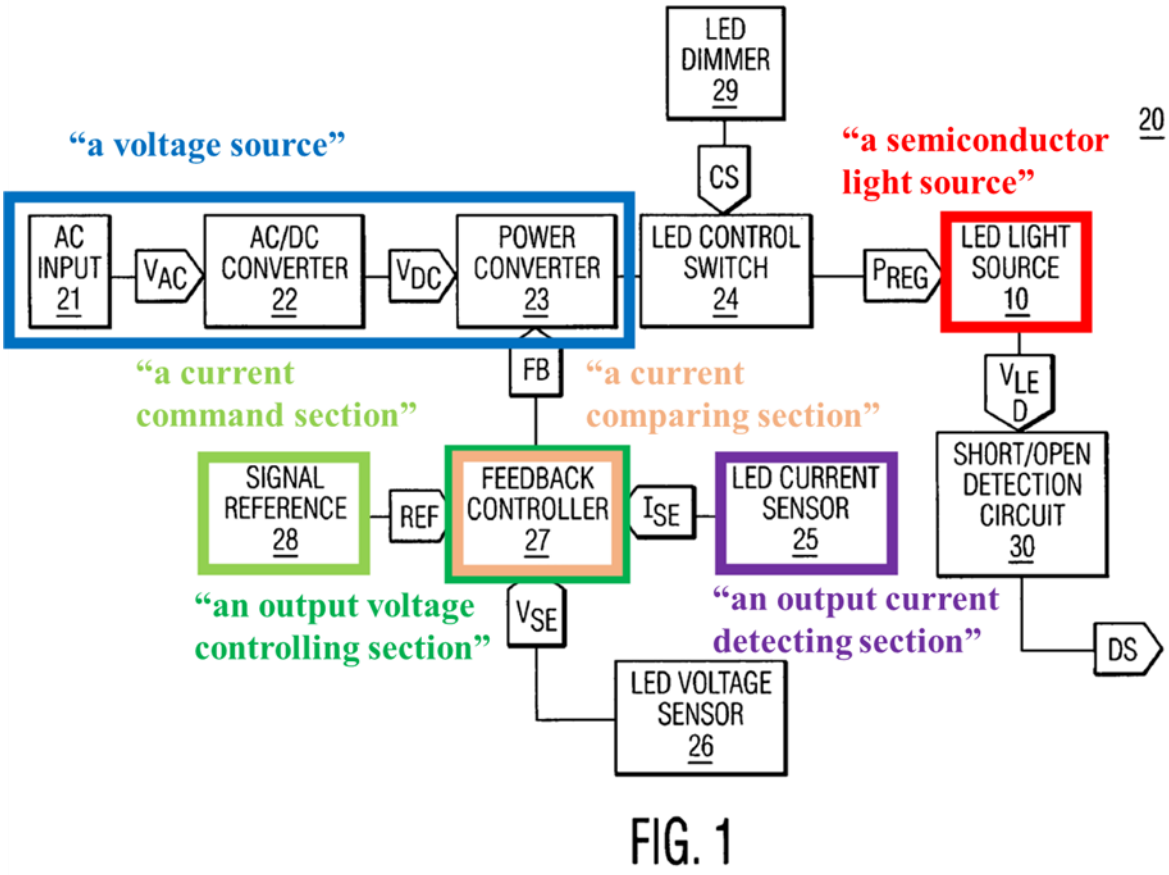


FIG. 1

Tripathi at Figure 1 (annotated).

c. Motivation to Apply Nishimura's Teachings to Tripathi

183. Tripathi and Nishimura are in the same field as the '830 Patent and pertinent to the problems addressed by the '830 Patent. For example, the '830 Patent's field includes LED driving circuits and the '830 Patent purports to address the problem of controlling LED light intensity. '830 Patent at 1:16-18 ("The technical field relates to a semiconductor light source driving apparatus and semiconductor light source driving method that are suitable for display devices."), 3:16-20 ("However, with the technique disclosed in Patent Literature 1, the response upon stable operation depends on the response of the slower control loop, and, therefore, the response upon

light adjustment depends on the response of the slower control loop."), 3:47-54 ("Accordingly, in constant-current control according to a conventional control loop, it is difficult to maintain constant control characteristics because the control loop round trip gain ('control loop gain' or simply 'loop gain') changes depending on the value of the voltage that is applied to an element. That is, it is difficult with conventional constant-current control to adjust light of a semiconductor light source stably."), 4:32-5:3 ("That is to say, seen from the power supply side, the impedance of a semiconductor light source generally changes according to the drive current value … there is a problem that, due to the electrical characteristics of the semiconductor light source, the control loop gain changes depending on whether the drive current value is great or small, thereby changing current control performance … The object is to provide a semiconductor light source driving apparatus and semiconductor light source driving method that can achieve constant control performance regardless of whether the drive current value is great or small when a drive current value is increased and decreased while light is adjusted."), 5:45-50 ("The semiconductor light source driving apparatus and semiconductor light source driving method according to the present invention can achieve constant control performance regardless of whether a drive current value is great or small when the drive current value is increased and decreased while light is adjusted.").

184. Tripathi's field includes LED driving circuits as well, and Tripathi is pertinent to the problem of controlling LED light intensity. Tripathi at 1:9-10 ("The technical field of this disclosure is power supplies, particularly, a power supply for LEDs."), 1:22-36 ("The electrical characteristics of LEDs are such that small changes in the voltage applied to the LED lamp will cause appreciable current changes. In addition, ambient temperature changes will also result in LED current changes by changing the forward drop across the LEDs. Furthermore, the lumen output of LEDs depends on the LED current. The existing electrical power supplies for LED light

sources are not designed to precisely regulate the LED current to prevent luminous intensity variations due to input ac voltage variations and ambient temperature. Operation of LED lamps at excessive forward current for a long period can cause unacceptable luminous intensity variations and even catastrophic failure. In addition, current electrical power supplies do not minimize power consumption to maximize energy savings.").

185. Nishimura's field also includes LED driving circuits, and it is pertinent to the problem of controlling LED light intensity. Nishimura at 1:7-23 ("Temperature, aging and other factors can lead to a shift in the intensity of light emitted by a light emitting diode (LED). When a light source is formed from a plurality of LEDs, shifts in the intensities of the light source's individual LEDs can lead to a shift in the light source's color point … discloses how to 1) measure the spectral content of an LED light source using one or more photosensors, and then 2) alter the operating current(s) of one or more of the light source's LEDs in response to the measured spectral content, to thereby maintain the light source's color point."), 1:27-31 ("In one embodiment, an operating current of an LED is varied and, at one or more values of the operating current, a corresponding voltage of the LED is measured. The measured voltages are then used as feed-forward variables to set the light intensity of the LED."), 2:7-21 ("A shift in the intensity of light emitted by an LED may be precipitated by factors such as a change in temperature of the LED's junction, or aging effects. Previously, these shifts have been accounted for by using a photosensor to sense the LED's light, and then regulating the LED's operating current in response to the sensed light … there are times when implementing the photosensor required to sense the LED's light is just too costly, too complex, or impractical to implement.").

186. A person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings to Tripathi's LED driver circuit. Such an

implementation would have advantageously enhanced the reliability of the circuit by "closely predict[ing] the intensity of light emitted by an LED as a function of … operating current" that "can then be used to set the light intensity of an LED." Nishimura at 2:22-34. Thus, Nishimura teaches that the voltage and current characteristics are read directly from the LEDs.

187. On the other hand, Tripathi discloses "short/open detection circuit 30" that provides "an indication of a short condition or an open condition of LED light source 10," but it does not disclose changing the voltage and current supplied to the LEDs based on temperature effects. Tripathi at 2:56-59. However, Tripathi recognizes that "ambient temperature changes … result in LED current changes by changing the forward drop across the LEDs." Tripathi at 1:22-36. Nishimura discloses that "LED's junction temperature and aging effects" are functions of "the LED's dynamic impedance" and discloses estimating dynamic impedance to account for such variations. Nishimura at 2:7-25, 4:54-58, Claims 18, 24. Thus, applying Nishimura's impedance detection teachings in implementing Tripathi's LED driver circuit would have furthered Tripathi's objective of regulating output power to the LEDs to maintain a brightness.

188. Further, such an implementation would have advantageously enhanced the reliability of the system by regulating the output power and setting the proper light intensity of the LEDs based on another feedback factor (dynamic impedance), instead of just based on sensed current, sensed voltage, and a reference current signal. Implementing Tripathi's LED driver circuit to account for a detected impedance, as taught by Nishimura, would be nothing more than applying a known technique of impedance detection to a known device ready for improvement to yield predictable results of accounting for junction temperature and aging effects in addition to load current when setting a light intensity of LEDs.

189. In implementing Nishimura's impedance detection teachings in Tripathi's driver circuit, a person of ordinary skill in the art would have understood or at least found it obvious that the feedback controller would estimate the dynamic impedance of the LEDs, as the feedback controller receives "a sensed voltage V_{SE} indicative of a magnitude of the LED voltage V_{LED} applied to LED light source 10" and "a sensed current I_{SE} indicative of a magnitude of the LED current flowing through LED light source 10." Tripathi at 2:28-42. It would have been obvious for the feedback controller to estimate the dynamic impedance by dividing the sensed voltage by the sensed current. See Nishimura at 2:60-3:18 ("estimate the dynamic impedance of the LED" using "$\Delta V/\Delta I=R$; where ΔV is the difference in two measured voltages of the LED, where ΔI is the difference in the currents corresponding to the measured voltages, and where R is the LED's dynamic impedance"). A person of ordinary skill in the art would have recognized the benefits in using the dynamic impedance, in addition to the sensed current, sensed voltage, and signal reference, to "provide[] a feedback signal FB to power converter 23" to "regulate[] power P_{REG} including a LED current and a LED voltage V_{LED}," as such an implementation would have advantageously enhanced the reliability of the circuit as discussed above. Tripathi at 2:24-42, Figure 1.

190. A person of ordinary skill in the art would have had a reasonable expectation of success in applying Nishimura's impedance detection teaching in implementing Tripathi's driver circuit. For example, it was known in the art to use dynamic impedance measurements to "set an operating current" of LEDs. Nishimura at 4:54-58, Claims 18, 24. A person of ordinary skill in the art would have also had a reasonable expectation of success in applying Nishimura's impedance detection teachings in implementing Tripathi, as both references teach feedback control to maintain voltage supplied to and current drawn from LEDs. Tripathi at Abstract, 2:18-42;

Nishimura at Abstract, 4:54-58. Further, both Tripathi and Nishimura disclose using control circuitry to regulate the brightness of the LEDs, and implementing Nishimura's impedance detection teaching in Tripathi's feedback controller would have merely required using the already sensed current and voltage measurement to calculate the impedance. This would have been a straightforward application of Nishimura's impedance detection teachings in a manner that advantageously improves Tripathi's driver circuit. Thus, a person of ordinary skill in the art would have found it straightforward and advantageous to apply Nishimura's impedance detection teachings to Tripathi's driver circuit, and would have known such a combination (yielding the claimed limitations) would predictably work and provide the expected functionality.

d. <u>Claim 1</u>

i. 1(pre): "1. A semiconductor light source driving apparatus comprising:"

191. This limitation is disclosed by Tripathi.

192. To the extent the preamble is limiting, Tripathi discloses a semiconductor light source driving apparatus (*e.g.*, "a power supply for LEDs"). Tripathi at Abstract, 1:9-10.

193. For example, Tripathi discloses a "power supply (20) for LEDs [that] provides power to a LED light source." Tripathi at Abstract, 1:9-10 ("The technical field of this disclosure is … a power supply for LEDs."), Figs. 1-2.

194. A person of ordinary skill in the art would have understood that an LED is a semiconductor light source. *See* '830 Patent at 1:24-25 (Patent Owner admitting "[s]emiconductor light sources include … light-emitting diodes" in the prior art). Further, a person of ordinary skill in the art would have understood that a "diode" is a semiconductor.

ii. 1(a): "a semiconductor light source that is driven by a current;"

195. This limitation is disclosed by Tripathi.

196. Tripathi discloses a semiconductor light source that is driven by a current (*e.g.*, "LED current through the LED light source 10"). Tripathi at 2:18-36.

197. See my discussion of element 1(pre) above (Section XI.B.d.i).

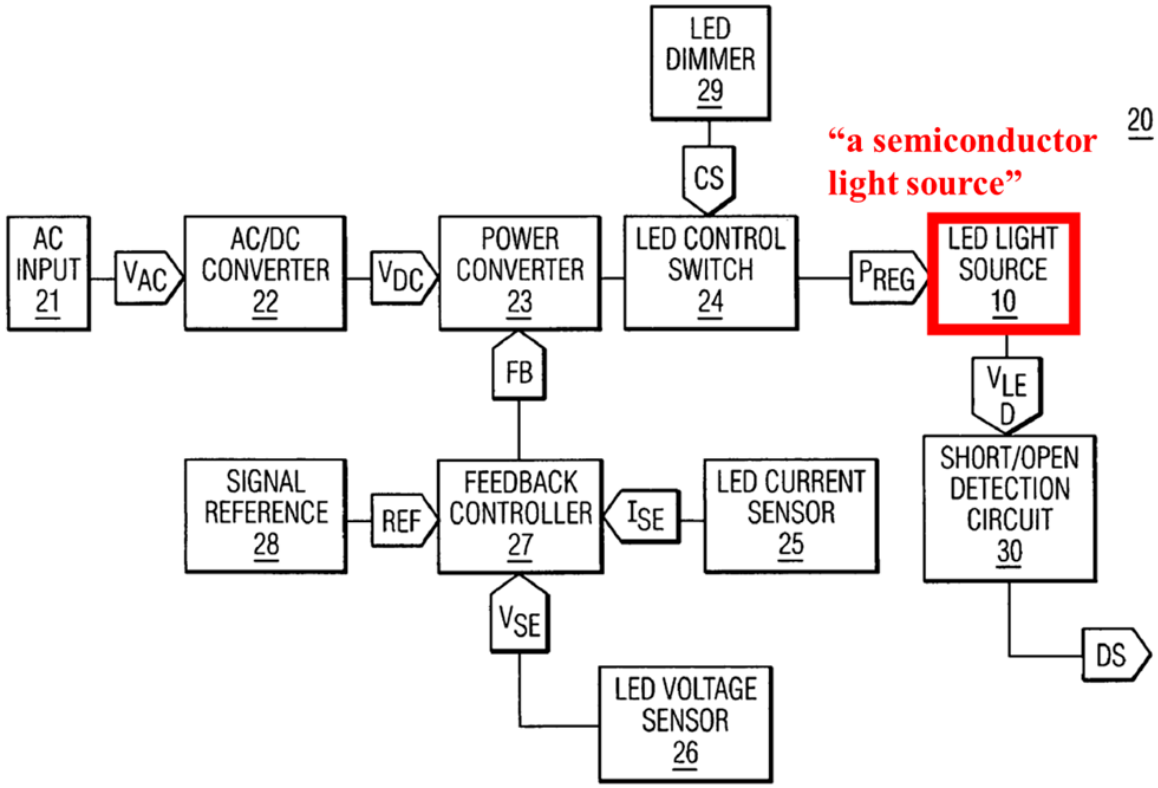


FIG. 1

Tripathi at Figure 1 (annotated).

198. For example, Tripathi further discloses "power converter 23" that "generates a regulated power P_{REG} including a LED current and a LED voltage V_{LED}" provided to "LED light source 10." Control switch 24 "controls a flow of the LED current through the LED light source 10." Tripathi at 2:18-31.

iii. 1(b): "a voltage source that drives the semiconductor light source;"

199. This limitation is disclosed by Tripathi.

200. Tripathi discloses a voltage source (*e.g.*, "single-phase ac input 21," "AC/DC converter 22," and a "power converter 23") that drives the semiconductor light source (*e.g.*, "provides regulated" "LED current and a LED voltage" to "LED light source 10"). Tripathi at 2:18-27, 3:12-26.

201. See my discussion of element 1(a) above (Section XI.B.d.ii).

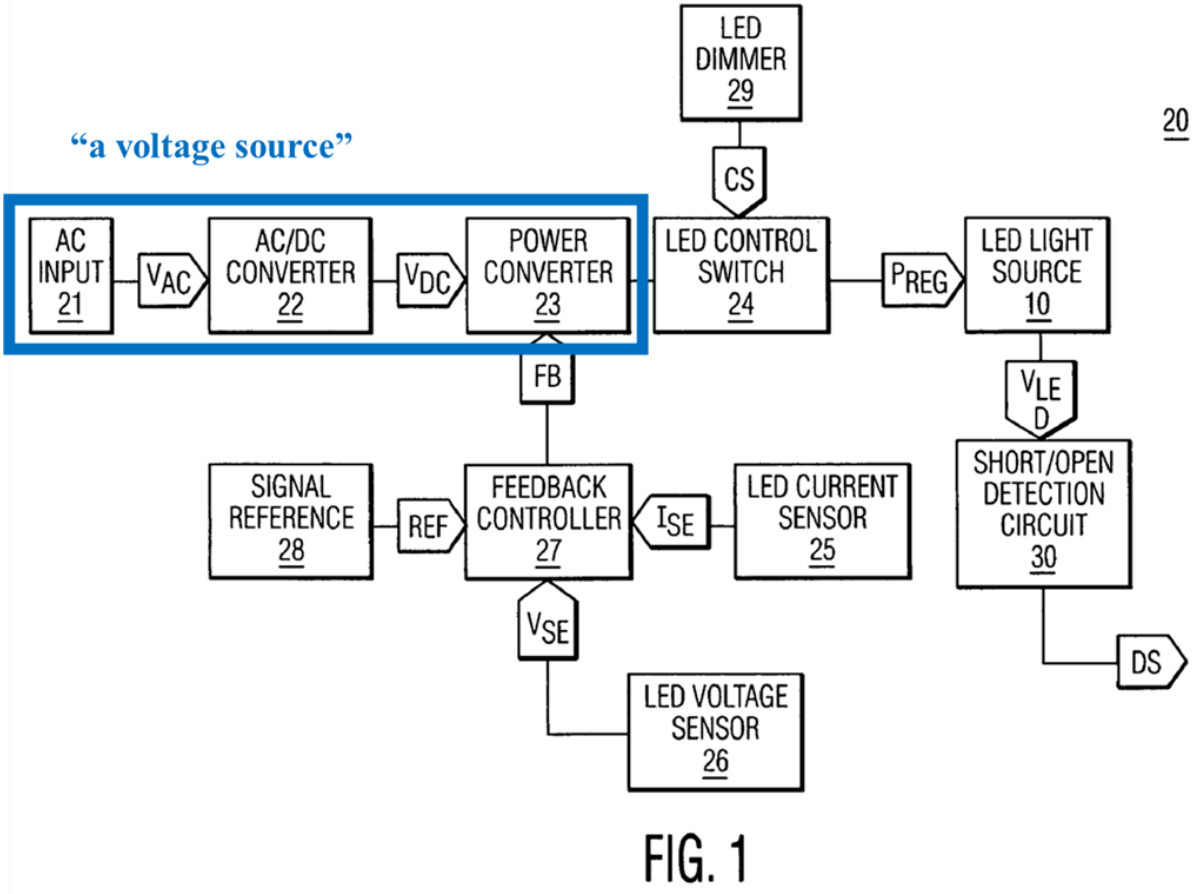


FIG. 1

Tripathi at Figure 1 (annotated).

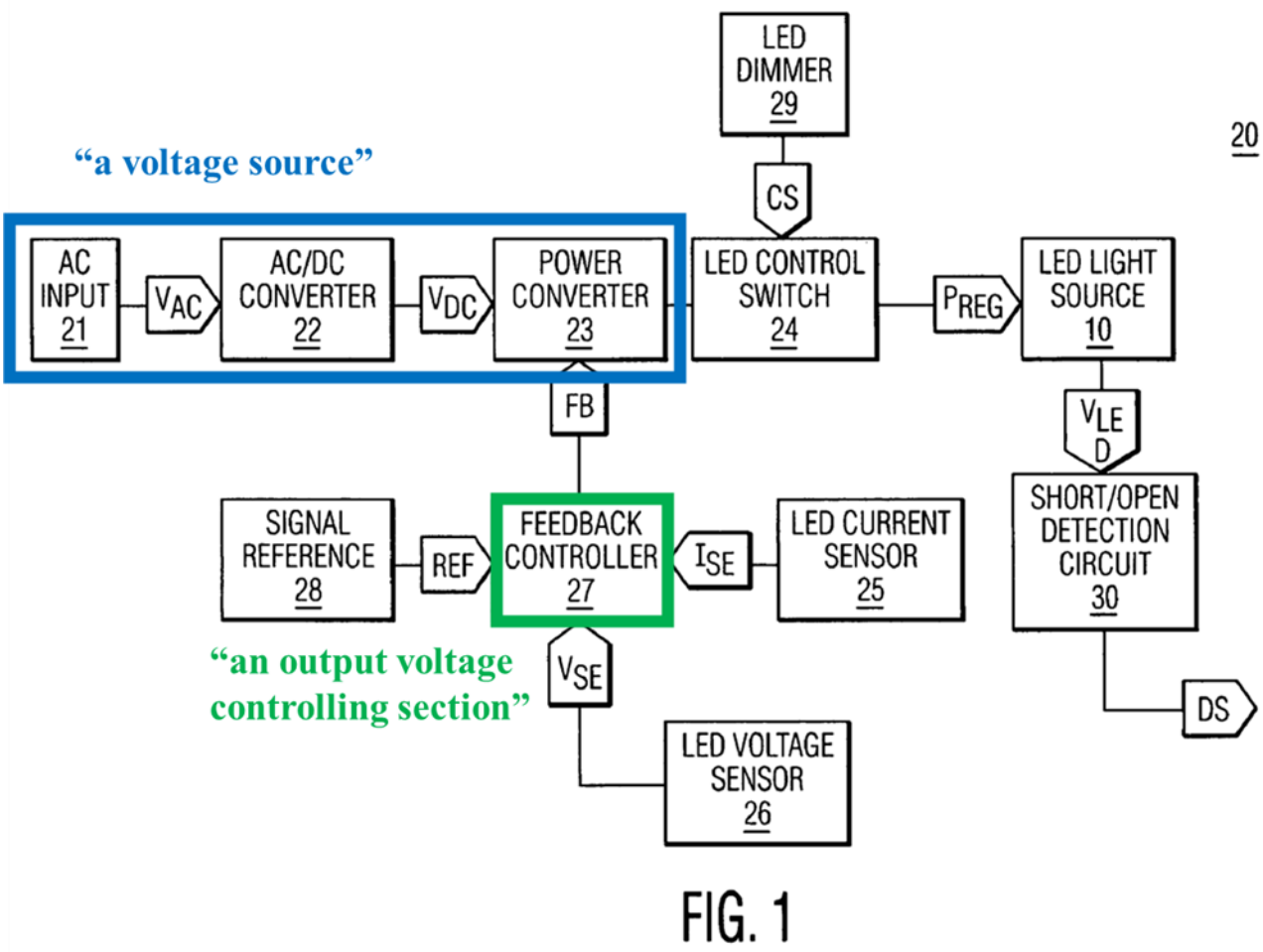
202. For example, Tripathi further discloses power supply 20 includes a "single-phase ac input 21" that "provides a voltage V_{AC} to an AC/DC converter 22," which "converts voltage V_{AC} into a voltage V_{DC}." Tripathi at 2:18-24. The V_{DC} is provided "to a power converter 23" that "generates a regulated power P_{REG} including a LED current and a LED voltage V_{LED}" that is supplied to the LEDs. Tripathi at 2:24-27, 3:12-26.

iv. 1(c): "an output voltage controlling section that controls a drive current value for driving the semiconductor light source by controlling an output voltage of the voltage source;"

203. This limitation is disclosed by Tripathi.

204. Tripathi discloses an output voltage controlling section (*e.g.*, "feedback controller") that controls a drive current value (*e.g.*, "regulat[ing] power P_{REG} including a LED current") for driving the semiconductor light source (*see* 1(a)) by controlling an output voltage of the voltage source (*e.g.*, "regulat[ing] power P_{REG} including … LED voltage V_{LED}"). Tripathi at 2:18-42, Figure 1.

205. See my discussion of elements 1(a)-1(b) above (Sections XI.B.d.ii-iii).



Tripathi at Figure 1 (annotated).

206. For example, Tripathi further discloses a "feedback controller" that receives "[s]ensed current I_{SE} and sensed voltage V_{SE}" and "reference signal REF." Tripathi at 2:24-42. Based on these inputs, "provides a feedback signal FB to power converter 23" to "regulate[] power P_{REG} including a LED current and a LED voltage V_{LED}" supplied to the LEDs. Tripathi at 2:24-42. Thus, the feedback controller controls the LED current supplied to the LEDs by controlling the output voltage of the power converter.

v. 1(d): "an output current detecting section that detects an output current of the semiconductor light source;"

207. This limitation is disclosed by Tripathi.

208. Tripathi discloses an output current detecting section (*e.g.*, "LED current sensor 25") that detects an output current of the semiconductor light source (*e.g.*, "sense[s] … a magnitude of the LED current flowing through LED light source")**.** Tripathi at 2:31-33, 3:40-44.

209. See my discussion of elements 1(a)-1(b) above (Sections XI.B.d.ii-iii).

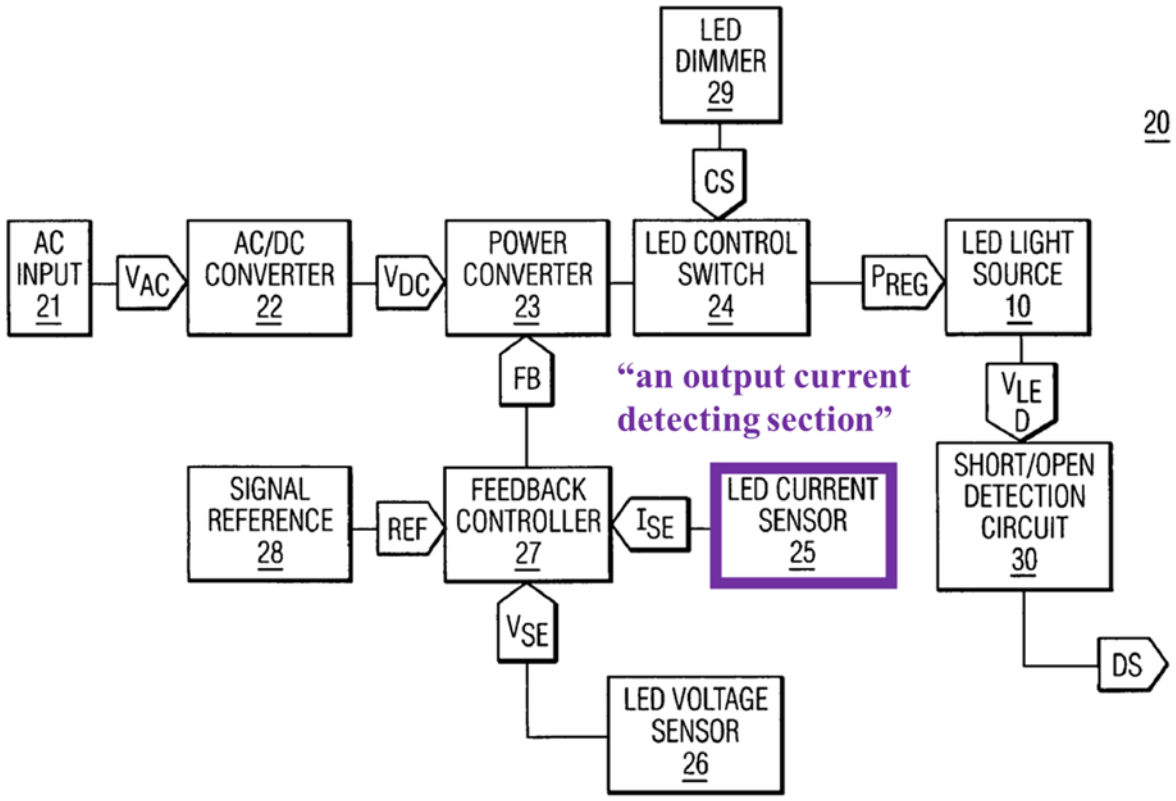


FIG. 1

Tripathi at Figure 1 (annotated).

210. For example, Tripathi further discloses a "LED current sensor 25" that "sense[s] LED current I_{SE}," which is a "voltage representative" of the "magnitude of the LED current flowing through LED light source." Tripathi at 2:31-33, 3:40-44.

vi. 1(e): "a current command section that specifies a reference value of a drive current which is applied to the semiconductor light source;"

211. This limitation is disclosed by Tripathi.

212. Tripathi discloses a current command section (*e.g.*, "signal reference 28") that specifies a reference value (*e.g.*, "REF") of a drive current which is applied to the semiconductor light source (*e.g.*, "reference current signal" for "LED light source 110"). Tripathi at 2:38-42, 3:24-35.

213. See my discussion of elements 1(a) and 1(c)-1(d) above (Sections XI.B.d.ii and iv-v).

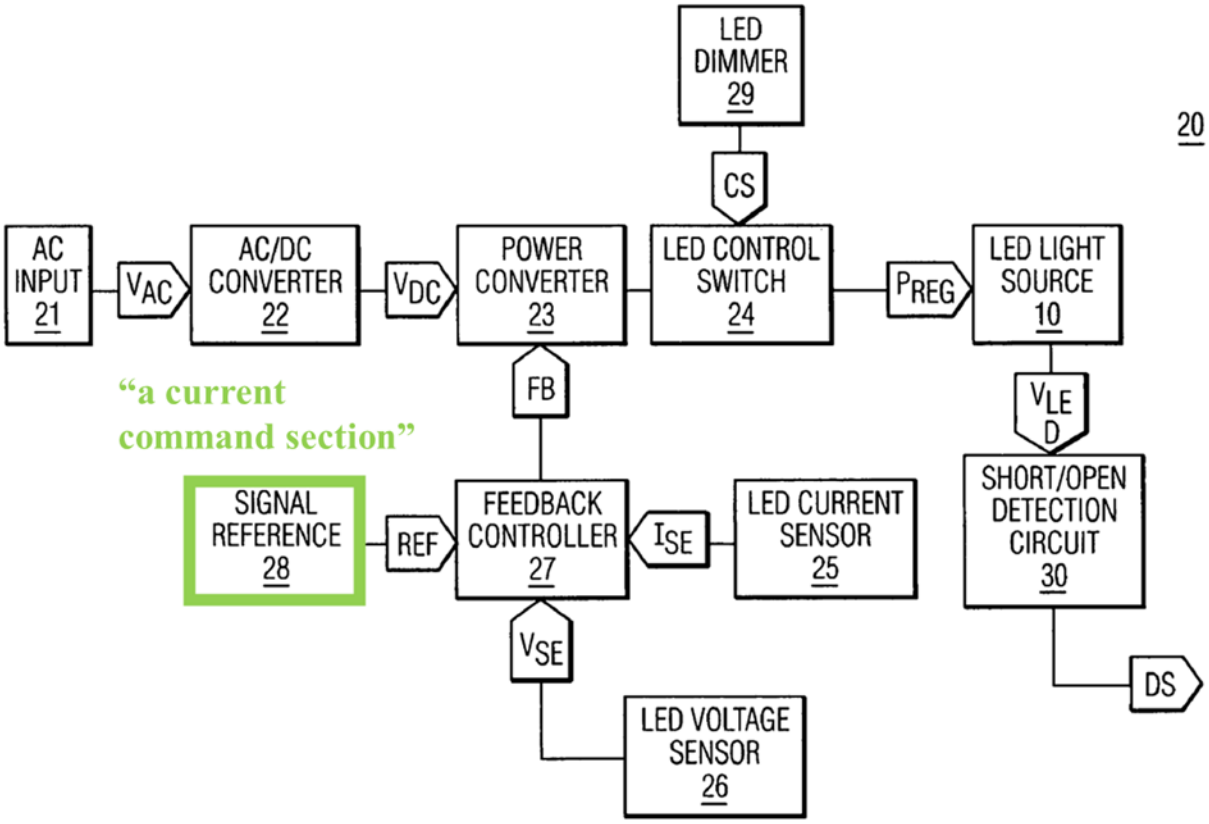


FIG. 1

Tripathi at Figure 1 (annotated).

214. For example, Tripathi further discloses "signal reference 28" that provides a "reference current signal" to feedback controller 27 to control the voltage and current supplied to the LEDs, as discussed in 1(c). Tripathi at 2:38-42, 3:24-35, Figure 1. A person of ordinary skill in the art would have understood or at least found it obvious that the reference current signal is a reference drive current applied to the LEDs. For example, a person of ordinary skill in the art would have understood or at least found obvious that the reference current signal is associated with a value at which the output voltage and current supplied to the LEDs is set, as the output voltage

and current is adjusted based on the reference signal's value. A person of ordinary skill in the art would have understood or at least found it obvious that by changing the reference current signal value, the output voltage and current supplied to the LEDs would also change.

vii. 1(f): "a current comparing section that compares the output current detected by the output current detecting section and the reference value specified by the current command section; and"

215. This limitation is disclosed by Tripathi.

216. Tripathi discloses a current comparing section that compares the output current detected by the output current detecting section and the reference value specified by the current command section (*e.g.*, "feedback controller" "compares sensed current … to a reference signal"). Tripathi at Abstract, 2:38-42, 3:40-52.

217. See my discussion of elements 1(a) and 1(c)-1(e) above (Sections XI.B.d.ii and iv-vi).

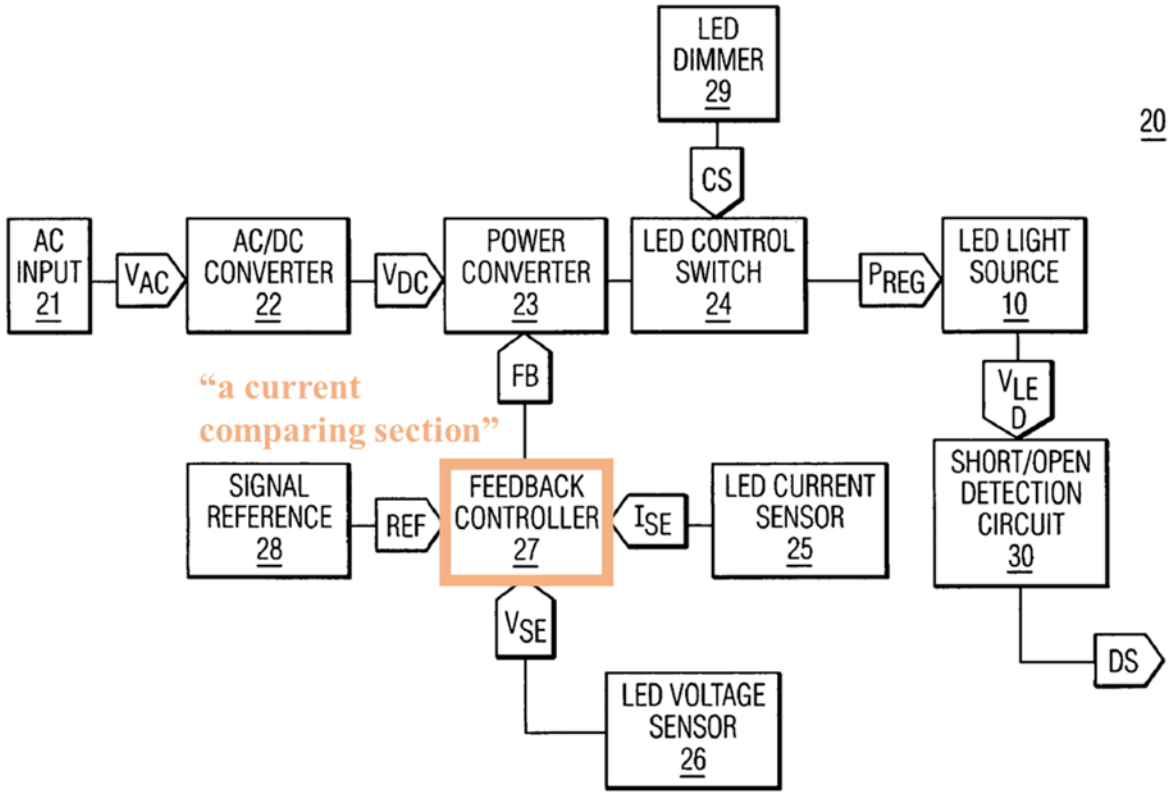


FIG. 1

Tripathi at Figure 1 (annotated).

218. For example, Tripathi further discloses that the feedback controller "compares sensed current" I_{SE} (*see* 1(d)) to the "reference current signal" (*see* 1(e)). Tripathi at Abstract, 2:38-42, 3:40-52. The feedback controller generates the feedback signal based on these inputs. Tripathi at Abstract, 2:38-42, 3:40-52.

viii. 1(g): "an impedance detecting section that detects an impedance of the semiconductor light source,"

219. This limitation is disclosed by Nishimura, and alternatively rendered obvious by Tripathi.

220. Nishimura discloses an impedance detecting section that detects an impedance of the semiconductor light source (*e.g.*, "control circuitry 506" that "acquire[s] readings from the

[LEDs'] current and voltage sensors 502, 504" and "estimate[s] a dynamic impedance of the LED[s]")**.** Nishimura at 4:54-58, Claims 18, 24.

221. *See* my discussion of element 1(g) in Ground 1 above (Section XI.A.f.viii).

222. As discussed in Section XI.B.c, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Tripathi's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance.

223. Alternatively, Tripathi renders obvious an impedance detection section that detects an impedance of the semiconductor light source. For example, as discussed in 1(d), the feedback controller already receives "[s]ensed current I_{SE} and sensed voltage V_{SE}" to generate "a feedback signal FB to power converter 23" to "regulate[] power P_{REG} including a LED current and a LED voltage V_{LED}" supplied to the LEDs. Tripathi at 2:24-42. For the same reasons discussed in Ground 1, 1(g) (§IX.A.f.viii), it would have been obvious to use the sensed current I_{SE} and sensed voltage V_{SE} to calculate an impedance of the LEDs to advantageously account for LED junction temperature and aging effects, which were known factors a person of ordinary skill in the art would have been aware of that affect LED brightness. And at minimum, a person of ordinary skill in the art would have been motivated to apply these Nishimura's teachings to Tripathi for these same reasons.

ix. 1(h): "wherein the output voltage controlling section controls the output voltage of the voltage source based on an output of the current comparing section and an output of the impedance detecting section."

224. This limitation is rendered obvious by Tripathi in view of Nishimura, and alternatively Tripathi alone.

225. Tripathi discloses the output voltage controlling section controls the output voltage of the voltage source (*see* 1(c)) based on an output of the current comparing section (*e.g.*, output "voltage feedback V_{FB} from feedback controller"). Tripathi at 3:45-49.

226. See my discussion of elements 1(b)-1(c) and 1(f) above (Sections XI.B.d.iii-iv and vii).

227. For example, as discussed in 1(c) and 1(f) (Sections XI.B.d.iv and vii), Tripathi discloses the "feedback controller" provides "regulate[d] … LED voltage V_{LED}" to the LEDs based on "feedback signal FB" that includes the result when "compar[ing] sensed current … to a reference signal." Tripathi at Abstract, 2:24-42, Figure 1.

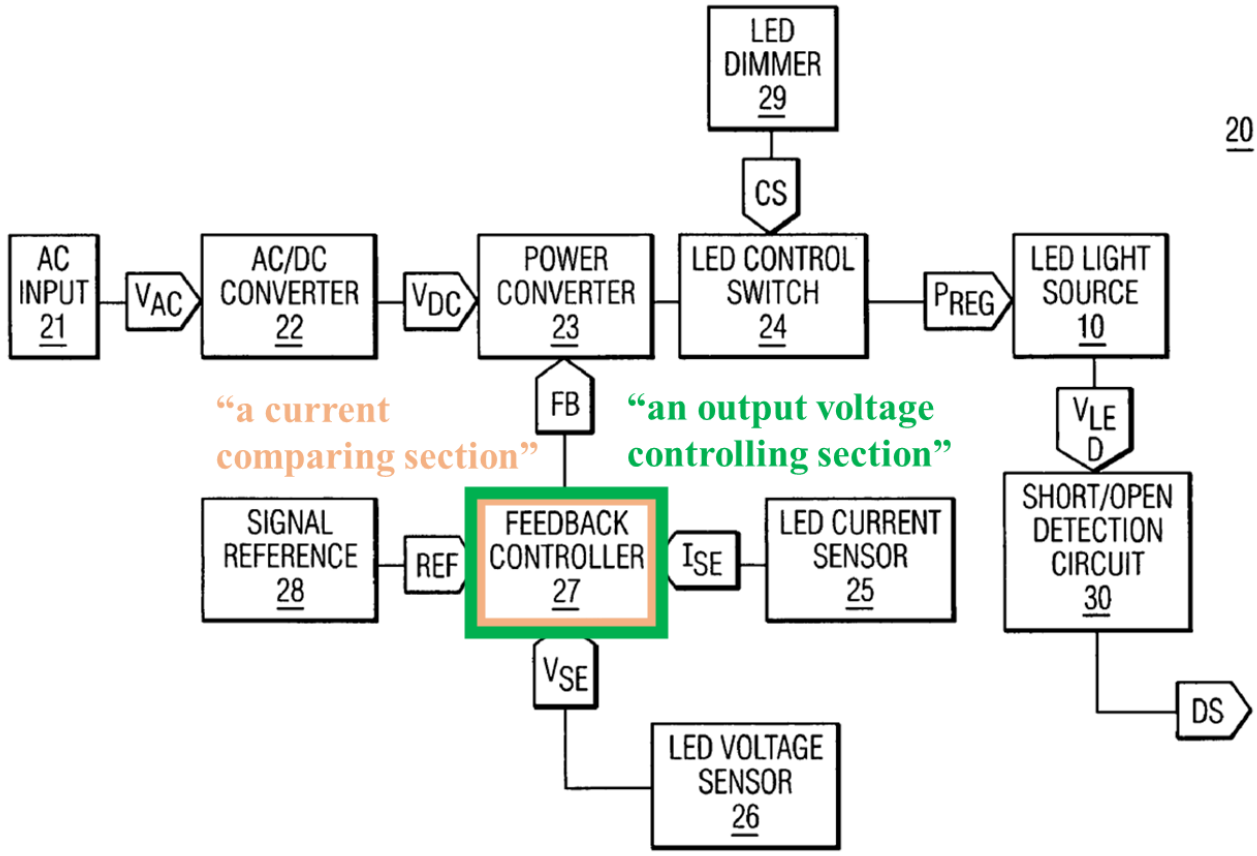


FIG. 1

Tripathi, Fig. 1.

228. Nishimura discloses controlling the output voltage of the voltage source based on the impedance detecting section (*see* 1(g)).

229. As discussed in Section XI.B.c, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Tripathi's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance. As also discussed in Section XI.B.c, in implementing Nishimura's impedance detection teachings in Tripathi's circuit, the feedback controller would have controlled the output voltage of the power converter based on the detected impedance result as taught by Nishimura.

230. Alternatively, Tripathi renders obvious the output voltage controlling section controls the output voltage of the voltage source based on an output of the current comparing section and an output of the impedance detecting section. For example, as I discussed in connection with limitation 1(g), it would have been obvious to implement Tripathi to use the already sensed current and voltage to calculate the impedance of the LEDs. For the same reasons discussed in Ground 1, 1(g) (§IX.A.f.viii), it would have been obvious to use that result to "regulate[] power P_{REG} including a LED current and a LED voltage V_{LED}" supplied to the LEDs by generating a feedback signal that accounts for the impedance calculation. Tripathi at 2:24-42. And at minimum, a person of ordinary skill in the art would have been motivated to apply these Nishimura teachings to Tripathi for these same reasons.

e. <u>Claim 2</u>

231. Claim 2 recites "The semiconductor light source driving apparatus according to claim 1, wherein the impedance detecting section comprises a divider that divides the output voltage of the voltage source by the output current detected by the output current detecting section,

and acquires a value corresponding to the impedance of the semiconductor light source from an output of the divider."

232. Tripathi in view of Nishimura renders obvious claim 1 (Section XI.B.d).

233. Tripathi discloses the output voltage of the voltage source (*see* 1(c), 1(h)), the output current detected by the output current detecting section (*see* 1(d)), and the semiconductor light source (*see* 1(a)).

234. Nishimura discloses that the impedance detecting section comprises a divider that divides voltage by current and acquires a value corresponding to the impedance from an output of the divider.

235. See my discussion of claim 2 in Ground 1 above (Section XI.A.g).

236. As discussed in Section XI.B.c, a person of ordinary skill in the art would have been motivated to apply Nishimura's impedance detection teachings in implementing Tripathi's circuit to advantageously enhance the reliability of the circuit by detecting both load current and dynamic impedance.

f. Claim 5

237. As discussed above, the limitations of claim 5 are subsumed within claim 1. See my comparison of the claims above in Section VII.D (table correlating claim 5 with claim 1).

238. Claim 5 is rendered obvious by Tripathi for the same reasons as described above regarding Ground 2, Claim 1 (Section XI.B.d).

XII. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS REGARDING THE CHALLENGED PATENT

239. During prosecution of the Challenged Patent, the applicants did not discuss any secondary considerations of non-obviousness, and I am not aware of any secondary considerations that would support non-obviousness. Indeed, per my discussion of the prior art referenced herein,

any purported solutions to problems or unexpected results in the ’830 Patent were already well known. Should the Patent Owner put forth any alleged evidence of secondary considerations in connection with the Challenged Patent, I reserve the right to consider such evidence, to consider whether any such evidence has a nexus to any claims of the Challenged Patent, and to update my analysis.

XIII. CONCLUSION

240. In summary, I have concluded that the Challenged Claims are rendered obvious over the prior art references as discussed above. Specifically, in my opinion, for at least the reasons above, the Challenged Claims of the ’830 Patent are disclosed and rendered obvious as follows.

Ground	Claims	Prior Art References
1	1-5	Ghanem in view of Nishimura
2	1-2 and 5	Tripathi in view of Nishimura

241. To the extent it is argued that any further disclosure is required for an element in the Challenged Claims that I have identified as being disclosed, a person of ordinary skill in the art would certainly have found that element obvious to include based on the sample explicit disclosure or inherent disclosures and analysis I have identified above.

242. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner or its expert(s) may raise and to take into account new information as it becomes available to me.

243. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me,

I will appear for cross-examination within the United States during the time allotted for cross-examination.

244. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner or its expert(s) may raise and to take into account new information as it becomes available to me.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on July 28, 2025 in New York, NY.

Respectfully submitted,

Alex Z. Kattamis, Ph.D., P.E.

APPENDIX A

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Engineering & Scientific Consulting

Alex Kattamis, Ph.D., P.E, CFEI, CVFI

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Professional Profile

Dr. Kattamis is an electrical engineer with an extensive background in failure analysis and forensic engineering. He performs root cause analyses (RCA) relating to failures and fires in electrical systems ranging from semiconductor devices and consumer electronics to power generation, transmission and distribution equipment.

Dr. Kattamis has also led large-scale condition assessments of mechanical, electrical, and plumbing (MEP) systems following natural disasters. He has an in depth knowledge of relevant electrical codes and standards including those of the IEC, IEEE, NEC, NESC, NFPA, OSHA, and UL.

Dr. Kattamis has expertise in the design, fabrication, and failure analysis of semiconductor devices including thin-film electronics, flexible electronics, memories, LEDs, LCDs, AMOLEDs, integrated circuits, and printed circuit boards. Dr. Kattamis is also has experience in investigating and providing testimony in intellectual property matters.

Dr. Kattamis received his Ph.D. in Electrical Engineering at Princeton University. His research focused on large-area flexible electronics including the design, fabrication and characterization of TFT display backplanes for electrophoretic displays and AMOLEDs on metal foils and polymer substrates. This included significant work in thin-film mechanics. His fabrication experience includes plasma-enhanced chemical vapor deposition, reactive-ion etching, sputter deposition, wet chemical processing, and photolithography.

Prior to his Ph.D., Dr. Kattamis worked at General Electric Industrial Systems, where he designed and implemented electronic trip units and current sensing systems for metering and switchgear. This included analog electronics design, modeling, and firmware coding.

Academic Credentials & Professional Honors

Ph.D., Electrical Engineering, Princeton University, 2007

M.A., Electrical Engineering, Princeton University, 2004

B.S.E., Electrical Engineering, University of Connecticut, 2002

Princeton Plasma Physics Fellowship Recipient

Tau Beta Pi

Eta Kappa Nu

McGraw Graduate Fellow

General Electric Student Intern Award Recipient

Citigroup Scholarship Recipient

Licenses and Certifications

Professional Engineer, Georgia, #PE045381

Professional Engineer Electrical, Massachusetts, #55240

Professional Engineer, New Jersey, #24GE05592500

Professional Engineer, New York, #90343

Professional Engineer, Pennsylvania, #PE090289

Professional Engineer Electrical, Rhode Island, #PE.0013344

Professional Engineer Electrical and Computer, Texas, #137167

Certified Fire and Explosion Investigator (CFEI)

Certified Vehicle Fire Investigator (CVFI)

Prior Experience

Research Assistant; Princeton University (2002-2007)

Design Engineer; General Electric Industrial Systems (Summer 2001, 2002)

Professional Affiliations

Institute of Electrical and Electronic Engineers (member)

Society for Information Display (member)

Materials Research Society (member)

Languages

French

Greek

Publications

A. Z. Kattamis, P. F. Murphy, M. Pooley and A. Soane, "Water Infiltration in Common Residential and Commercial Power Cables Introduced by Capillary Action," 2020 IEEE Symposium on Product Compliance Engineering - (SPCE Portland), Portland, OR, USA, 2020, pp. 1-3, doi: 10.1109/SPCE50045.2020.9296167.

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Kattamis AZ, Murphy PF. Innovations in backplane electronics for large-area OLEDs. IEEE Long Island Systems, Applications and Technology Conference, Technology Track, Session 3, 2012.

Project Experience

Failure Analysis

- Root cause analysis of medical device failures

- Root cause analysis of lighting device failures
- Root cause analysis of failures in power strips used in data centers
- Hazard analysis for lighting devices
- Root cause analysis for motor run capacitor failures

Flexible Electronic Circuits

- Flexible aluminum substrate characterization
- Amorphous silicon thin-film transistor deposition
- Aluminum substrate passivation and coating for thin-film processing

Hard Disk Drives

- Patent and trade secret investigations relating to hard disk drive intellectual property
- Infringement analysis of accused hard disk drives products
- Prior art and validity analysis of patents related to hard disk drive patents

Light Emitting Devices

- Patent investigations relating to LED and laser diode intellectual property
- Reverse engineering focusing on device processing and characterization
- Infringement analysis of accused LEDs and laser diodes
- Prior art and validity analysis of patents related LEDs and laser diodes

Semiconductor Devices and Materials

- Patent investigations relating to semiconductor devices
- Reverse engineering focusing on packaging, processing and design of memories and other semiconductor devices
- Infringement analysis of accused memories and other semiconductor devices
- Prior art and validity analysis of patents related to memories and other semiconductor devices

Image Processing Software

- Reverse engineering focusing on image processing software and algorithms
- Infringement analysis of accused image processing products
- Prior art and validity analysis of patents related to image processing patents

Computer Networks

- Reverse engineering focusing on computer networks, including networks for providing financial services
- Infringement analysis of accused computer networking products

Fire Investigations

- Cause and origin of fires relating to wiring, electrical equipment and consumer electronics

CONTINUING EDUCATION (CFEI)

IAAI, “Explosion Dynamics, cfitrainer.net, July 31, 2015

IAAI, “The Practical Application of the Relationship Between NFPA 1033 and NFPA 921, cfitrainer.net, July 31, 2015

IAAI, “Electrical Safety, cfitrainer.net, August 12, 2015

IAAI, “The Potential Value of Electronic Evidence in Fire Investigations,” cfitrainer.net, August 17, 2015

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Principal Engineer

Testimony History

Innolux Corporation v. Semiconductor Energy Laboratory Co., Ltd., in the United States Patent and Trademark Office before the Patent and Trial Board, Case No. IPR2013-00064/65, 2013

Maxell, Ltd., et al., v. Huawei Device USA Inc., and Huawei Device Co., Ltd., in the United States District Court Eastern District of Texas, Case No. 5:17-cv-00033, 2019

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Zachry Industrial, Inc., v Three Phase Line Construction, Inc., in the United States District Court Southern District of Texas Houston Division, Civil Action No. 4:17-cv-3751, 2020

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